ENVIRONMENT

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PROFESSOR RATHINDRA NARAYAN BASU
EDITOR

UNIVERSITY OF CALCUTTA
2014

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ENVIRONMENT

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PROFESSOR RATHINDRA NARAYAN BASU
EDITOR

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CONTENTS

Page

CHAPTER I : FUNDAMENTALS OF ENVIRONMENT

1.1. Life and the environment 1

1.2. Non anthropogenic and anthropogenic changes in environment : natural and man-made disasters 8

1.3. Environmental hazards and risks 20

CHAPTER II : NATURE AND NATURAL PROCESSES

2.1. Planet earth — origin and evolution 22

2.2. Components of the earth 26

2.3. Climate of the earth 40

2.4. Natural cycles 53

CHAPTER III: ECOSYSTEM

3.1. Ecology and concept of ecosystem 65

3.2. Ecosystems of the world 68

3.3. Environment, flora and fauna : interrelations and interactions 72

3.4. Forest ecology 73

3.5. Problems of sustainability of ecosystems 74

CHAPTER IV : POPULATION AND ENVIRONMENT

4.1. Carrying capacity : limits to population growth 75

4.2.1. Population growth and natural resources 79

4.3.1. Impact of economic development on environment in India in particular 82

CHAPTER V : LAND AND WATER RESOURCES OF THE EARTH

5.1. Land resource of the earth 86

5.2. Land use 89

5.3. Water resource of the earth 95

CHAPTER VI : AIR, NOISE AND ODOUR POLLUTION

6.1. Air : an important resource of the earth 98

6.2. Greenhouse effect 110

6.3. Greenhouse gases, increase in global temperature and ozone hole 115

6.4. Ozone hole of the atmosphere 118
6.5. Noise pollution 122
6.6. Odorous pollutants 131

CHAPTER VII : ENERGY SOURCES

7.1. Sun as the ultimate source of energy 136
7.2. Energy and society 137
7.3. Conventional sources of energy 138
7.4. Non-conventional sources of energy 141
7.5. — 7.11. Wind, Tidal energy etc. 143

CHAPTER VIII: ENVIRONMENT AND PUBLIC HEALTH

8.1. Relation between environmental pollution and community health 146
8.2. Important water borne diseases 151
8.3. Human malaria parasites 156
8.4. Risk of using chemical insecticides etc. 161
8.5. Toxic actions of metals and biological substances 164

CHAPTER IX: POLLUTION AND WASTE MANAGEMENT

9.1. Water pollution 169
9.2. Treatment of waste water 172
9.3. Air pollution control technology 175
9.4. Persistent organic pollutants 182
9.5. Solid waste management 184

CHAPTER X : ENVIRONMENTAL POLICIES MOVEMENTS AND ETHICS

10.1. History of environmental institutions and instruments 186
10.2. Environment policies at the national level 190
10.3. Women and environment 194
10.4. Human rights issues relating to environment 201
10.5. National environment related movements 205
10.6. Environmental ethics 208

GLOSSARY 211

PREFACE

PREFACE

Environment encompasses virtually everything on earth and in a holistic ecological approach excludes almost nothing. As such, the natural world, the man-made technosphere along with its social and cultural aspects all come under the purview of environment.

The earth and environment existed albeit in somewhat different states, long before the present human, ***Homo sapiens***, came into the picture. Drastic changes in the physical, chemical and biological world along with environmental changes had been the natural phenomena taking place over millions of years which on a geological scale would be quite acceptable. What we are concerned today are short-term, basically man-made changes taking place over hundreds of years or changes that may happen over the next hundred or two hundred years, or in the next millennium, provided that we do have that much of foresight.

The concern about our environment which over the past few decades have been gradually shifting from local to global issues and perspectives need some amount of retrospection. Environmental degradation in our historical time scale is a more or less recent issue, more specifically since the beginning of the industrial revolution in Europe. Economic development and the urge for a higher and still higher standard of living led to uncontrolled burning of fossil fuels, large-scale deforestation for fuel-wood and timber and clearing land for food and commercial crops with consequent land degradation and soil erosion, excessive generation of wastes and effluents, all of which led to a significant decline in the quality of environment. And all these were associated with large increases in world population particularly in the developing and underdeveloped countries of the so-called third world. A time has come when we can no longer take environment for granted—hoping it to be as accommodative as we would wish — absorbing and assimilating all the abuses and assaults that the humankind in particular is inflicting on it. The signs of environmental degradation are all too explicit and evident to draw the serious attention and concern not only of experts and specialists but also of the general public.

Of course, in the period following the industrial revolution especially during the second half of the twentieth century there has been a significant progress — a great leap forward indeed, in the field of science and technology that gave the humankind opportunities and facilities unthinkable to our agrarian ancestors. Unfortunately, the phenomenal growth in science and technology has not been friendly to the environment in a large number of instances such as military applications of technological innovations, residual effects of pesticides, radiation hazards even from radioactive materials used for peaceful purposes. There is practically no let down of overexploitation of natural nonrenewable resources, burning of fossil fuels and waste generation from various sources. The greenhouse gases, global warming, widening of ozone holes and persistence in nature of toxic organic pollutants are indeed signs of an impending ecological catastrophe with far-reaching consequences. Are we so selfish and self-centred and foolish as to ignore our moral responsibility for the well being of our future generations at least for the next couple of hundred years or so?

Whatever may be the criticism of a biocentric approach of many ecologists it would be morally, ethically and biologically wrong to pursue an anthropocentric approach to the earth and environment.

Nevertheless, there is no point in losing hope and humankind is quite capable of reversing this trend. Already there are distinct positive signs : strict enforcement of environmental regulations for emission control have reduced acid rains by curtailing the release of oxides of sulphur and nitrogen into the atmosphere; historical monuments are being saved from corrosion by controlling the sources of emission, rivers such as the Thames and the Ganga and many others are being cleaned, reuse and recycling of wastes and composting for manures are now accepted practices. Wild life, inclusive of flora and fauna, whose importance need not be overemphasized in this era of biotechnology, when genes can be transferred across species and even flora-fauna barriers, are being protected along with the appreciation and realization of the great importance of biodiversity.

However, for success in this endeavour involvement of all concerned needs to be assured — all of us have collective as well as individual roles to play. A basic prerequisite in that effort would be awareness generation through an understanding of the environmental scenario via presentation of salient information on environment and related issues. The present publication is an attempt towards that direction aimed at a relatively concerned and informed audience with the hope that through them transmission of the major themes to the lower strata will automatically follow.

No subject is as multidisciplinary as environment which true to its definition is all pervasive and draws from practically all frontiers of knowledge and it is virtually impossible to exclude any branch of knowledge from the ambit of environment.

Keeping in view the multidisciplinary nature of environmental studies in which most branches of knowledge do have a fruitful convergence, the present text has been prepared by collaborative efforts of reputed persons in the fields of physics, chemistry, plant and animal biology, medicine, economics, technology and engineering and agriculture as well as environmentalists and women's rights activists. The format, scope and specific contents of the different chapters especially the extent of coverage were decided upon in several discussion meetings prior to embarking on the project.

There are ten chapters followed by a glossary of important terms and terminologies more frequently used in the literature on environment. The first chapter has been written by Professor Tarak Mohan Das which indeed gives an appropriate introduction and necessary background for the other chapters that follow. Professor Pijush Kanti Saha has prepared the texts for the second and fifth chapters. The basic aspects of the origin of the solar system, the evolution of the earth's lithosphere, hydrosphere, atmosphere and biosphere, the climate system and atmospheric disturbances, the gaseous and sedimentary cycles, have been covered to give the general reader an idea of the intricacies, interrelationships, balance and beauty of nature. In the fifth chapter the very important issues of land and water resources, including the various land use patterns, fresh water situation in the water budget, and hydrologic cycle have been deftly covered by Professor Saha. The need for a healthy ecosystem has been duly emphasized in the third chapter by Professor Subhendu Mukherji and Professor Naresh Chandra Datta who have briefly covered the salient features of the earth's ecosystems with specific examples of the flora and fauna in the different biomes of the world. Population and environmental issues have been elegantly dealt with in the fourth chapter by Professor Prabuddha Nath Ray highlighting the demographic transition over the years, the carrying capacity of the land, economic development vis-a-vis environment in the developed and developing countries emphasizing in particular, the plight of the third world countries trying hard for economic development in the face of population explosion, meagre nonrenewable resources, and local and global environmental problems created by the need for rapid industrialization. Dr. Jyoti Prokash Ghosh has discussed in details in the sixth chapter the genesis of air pollution and the various manifestations of gaseous and particulate pollutants along with a very informative section on greenhouse gases. Dr. Ghosh has also very lucidly outlined the problems of noise and odour pollution. Energy is a decisive factor in economic development, as such, the seventh chapter on energy sources by Professor Dilip Kumar Basu is of especial significance. Professor Basu has systematically covered the various aspects of energy sources and power generation and the merits and demerits of various technologies of power generation giving especial emphasis on the harnessing of nonconventional renewable sources in view of their environment-friendly sustainable nature. Dr. Amiya Kumar Hati has written the eighth chapter on the vital issue of environment and public health discussing at length the environment-related ailments and diseases and their possible remedies. Dr. Hati has emphasized the need for a prevention-oriented strategy in combating environment-triggered health problems of the community. Professor Binay Kanti Datta and Professor Sudip Kumar Banerjee have covered briefly the very important issue of pollution and waste management especially for municipal waste water and solid wastes, gaseous and particulate industrial pollutants, as well as the global problem of persistent organic pollutants and have rightly pointed out that pollution control at source, advanced and effective sewage treatment, recycling and reuse, and compost-making should be the acceptable methodologies in waste management. In the tenth chapter Professor Prabuddha Nath Ray, Dr. Ishita Mukherji, Dr. Ratnabali Chatterjee and Dr. Syamal Chakraborti have discussed in brief the salient features of the environmental policies and instruments, the very important issue of women in relation to environment in general and environmental degradation in particular, the legal hurdles in enforcing environmental regulations, Green Bench, important environment-related movements in the country, and in the concluding section, the ethical issues pertaining to the environment. Finally, the text has been supplemented by a glossary of selected environmental terms which it is hoped would be useful to the readers in having a ready acquaintance with the common terms used in the literature on environment. In fact, terms and terminologies of different disciplines quite often create artificial barriers. We believe that if the hurdles of less understood terms are overcome, the general reader will have a smooth sailing, even through the problem-ridden sphere of environment.

Although we have tried to avoid overlapping as far as practicable, to justify appropriate treatment of certain topics some amount of overlapping could not be avoided. In fact, in academic interest, that has been deliberately done in some of the chapters — with the view to making them self-explicit to a certain extent. Overall our venture has not been just dissemination of information but also to make those interested in the subject more and more involved in the environmental issues.

The editor thanks the Vice-Chancellor of the University of Calcutta, Professor Asis Kumar Banerjee, for his keen interest in the publication of this book and for agreeing to publish it from the Calcutta University Press. Professor Surabhi Banerjee, Pro-Vice-Chancellor for Academic Affairs, deserves our sincere thanks for her active interest in this publication. The editor is especially thankful to Professor Prabuddha Nath Ray who not only contributed two chapters but was deeply involved in the matter almost throughout the course of publication, and to his colleagues, associates and scholars, particularly Dr. Prativa Pal, Dr. Alak Kumar Mandal, Dr. Kalpana Sur, and Shri Bijay Kumar De who helped in various ways. The Superintendent of the Calcutta University Press Shri Pradip Kumar Ghosh and his team worked very hard to bring out this publication in a relatively short time and deserve special thanks for the same.

Lastly, although the publication is the outcome of a collaborative effort of all the contributors, the editor must thank all of them individually for extending utmost cooperation especially for giving full liberty in adding, revising and deleting certain parts of some of the manuscripts often without consultation. As such, responsibility for inadvertent errors rests with the editor and it is assured that in the subsequent edition of this publication due attention will be paid to correct or revise them and also incorporate relevant new information and ideas. Suggestions on that count would be most welcome.

Rathindranarayan Basu
Editor

CHAPTER I

FUNDAMENTALS OF ENVIRONMENT

1.1. Life and the environment

The earth is our home. Here we have all the essential requirements of life for a happy and purposeful living through generations. In this beautiful planet we have got a unique, congenial environment that makes our existence possible. Here we have water to satisfy our thirst, air to breathe, fertile soils to produce food, enough natural resources, e.g. forests, wild-life, coal, oil, minerals, etc., to improve our standard of living. Moreover, here we have a congenial temperature and plenty of sunlight, source of all energies, to make our lives enjoyable.

The universe is vast and almost infinite; however, barring future possibilities, we are not so far aware of the presence of life anywhere in the universe except in our planet. Life, is the most unique and precious treasure of this planet. The creation, evolution and sustenance of life on this planet has been possible only because of its extraordinary environment. On the other hand, it is also an undeniable fact that this life will become extinct from the face of the earth if its constant, active and beneficial links with the environment are disrupted, or environment itself is fatally degraded.

1.1.1. Meaning of the term environment

Environment is a broad term. It encompasses all that surrounds us, both the natural world in which we live and all the things produced by people. Biologists use the term environment in a general way to describe the total living and non-living things which influence the lives of organisms present in a specific area. In present times, the man-made environment of ferro-concrete cities, huge industrial complexes, and the various wastes from these palces are playing an increasingly important role in changing the environment which affects the life of every individual species of plant and animal inhabiting the place.

1.1.2. Life is dependent on environment

The basic components of the environment are plants, animals, air, water, soil, temperature and light. Plants and animals are the biotic components, and air, water, soil (excluding organisms living in the soil), temperature and light are the abiotic components.

Life is totally dependent on the environment. If it is a green plant, it would require sunlight, water and carbon dioxide of the air to synthesize sugar in the green parts of the plant by a process called photosynthesis. It also requires oxygen of the air for respiration and minerals of the soil to synthesize proteins and other vital organic compounds. Many species of plants do require assistance from the insects and other animals for pollination of their flowers and dispersal of seeds.

If it is an animal, it would require obligatory assistance from the green plants. Directly or indirectly, all animals live at the expense of green plants. They could be regarded almost as parasites of plants. A community without green plants would not survive; a community without animals would. Animals also require oxygen from the air and plenty of water and minerals from the environment. Both plants and animals require congenial temperature to maintain their life-processes. They cannot tolerate too high or too low a temperature and the degree of tolerance varies from species to species. Hence, temperature is a very important component of the environment, which, to a great extent, determines the habitats of plants and animals.

The most crucial feature of these environmental components lies in the fact that their quality, quantity and relative proportion among themselves are not all constant and easily changeable by man-made as well as natural forces. And when such changes occur various insurmountable problems appear before the plants and animals including human beings. Many of them try to adapt themselves to those changes, some prefer to leave the place forever, some of them are simply destroyed and become extinct. The balance in nature is thereby disturbed.

1.1.3. Recognition of the importance of environment in ancient India

Since the birth of human civilization ancient people used to recognize and respect the beneficial roles of sun, soil, air, water, etc. They used to worship sun, water, air, soil and various species of plants and animals of their environment.

Ancient Indian philosophers used to hold that the entire universe including earth, plants, animals and human beings is composed of five essential elements, e.g., *Khiti, Op, Teja, Marut* and *Byom* (i.e., earth, water, energy (sun, fire), air and void (empty space of the universe). Bodies of plants, animals and human beings are created out of these five essential elements, and after death, their bodies are disintegrated and converted back to these elements.

The fundamentals of conservation ethics were brilliantly formulated in the *Isho-Upanishad* : "The whole universe together with its creatures belong to Nature. Let no one species encroach over the rights and privileges of other species. One can enjoy the bounties of nature by giving up greed." In other words, if nature is over-exploited because of our greed, we stand to lose all its benefits.

In the Buddhist era a mass awareness was created for conservation of nature and natural resources. Killing of animals was discouraged and all sorts of violence, animosity and warfare were condemned. Instead, love, respect and reasoning had been promoted in the search for eternal truth of nature.

The recognition of environment depicted in our ancient scriptures is in conformity with the outlook of the present-day world to save the nature and formulate an effective strategy for the conservation of nature and natural resources.

1.1.4. Philosophy in environmental study

Every discipline has its own philosophy that helps to understand its ultimate goal, and establish the link and relationship with other disciplines. We have divided our scientific knowledge into a number of disciplines and pursue them separately, this artificial classification has got its own merits and demerits, but in nature most of those disciplines are working together in an intricate network of interrelationship creating almost endless amazing products with which nature has been sustaining its existence. A holistic approach is therefore imperative to understand its significance and ultimate objective.

An apple falls from the tree : it is the action of law of gravity. Sir Isaac Newton discovered it and that was indeed a great discovery. At least fifty startling scientific discoveries from the same phenomenon unknown to the scientific world on that day could, however, be made from that apparently very simple observation. A few of them may be cited here, — formation of abscission cell-layer that causes the apple to drop (Plant Physiology); action of enzyme polygalacturonidases that makes the apple soft and edible (Biochemistry); synthesis of protiens in the apple during ripening (Biochemistry); production of esters emanating characteristic flavour of the apple (Organic Chemistry); dormancy of apple seed that checks its germination while confined inside the fruit (Plant Physiology); and the genetic code of the apple species which is hidden inside every cell (in the chromosomes) of the embryonic tissue, that on germination will produce only apple plant and not some other plant (Molecular Genetics).

Our purpose of telling the story of the fall of the apple is to show how numerous scientific principles of widely diverse nature, almost beyond our comprehension, work together in a closely coordinated manner for manifesting a single natural phenomenon. From the philosophical point of view one simple but crucial question may be asked : "for what prupose?"

If any one would spend some time under the apple tree he could observe that a number of birds and numerous insects attracted by the delicious flavour, colour and sumptuous food reserve of the fruit hurriedly show up there and devour it, but not the seeds, as the seed coat contains the deadly toxic hydrocyanic acid. These seeds, under favourable condition, would break their dormancy and initiate a new generation and the ultimate goal of the apple-fall would be accomplished.

It is, therefore, quite apparent that the ultimate purpose of the series of extremely complex physical, chemical and biological reactions behind this simple natural event is to perpetuate the existence of the apple species on the earth. It may be the ultimate natural goal of all life-forms including human beings. In order to attain this goal a certainty of congenial environment is imperative which, however, is increasingly becoming uncertain with time.

1.1.5. The genesis of environmental problems

Life is not new in this world. The earliest traces of life on earth have been found in rocks about 3.5 billion (350 crore) years old. They are microscopic, laminated structures similar to those of today's marine bacteria. It is generally accepted that the first forms of life were some kind of bacteria. Such earliest forms of life have been evolved into millions of species and varieties of plants and animals and they are now stabilized on the earth through the development of a strategy of survival.

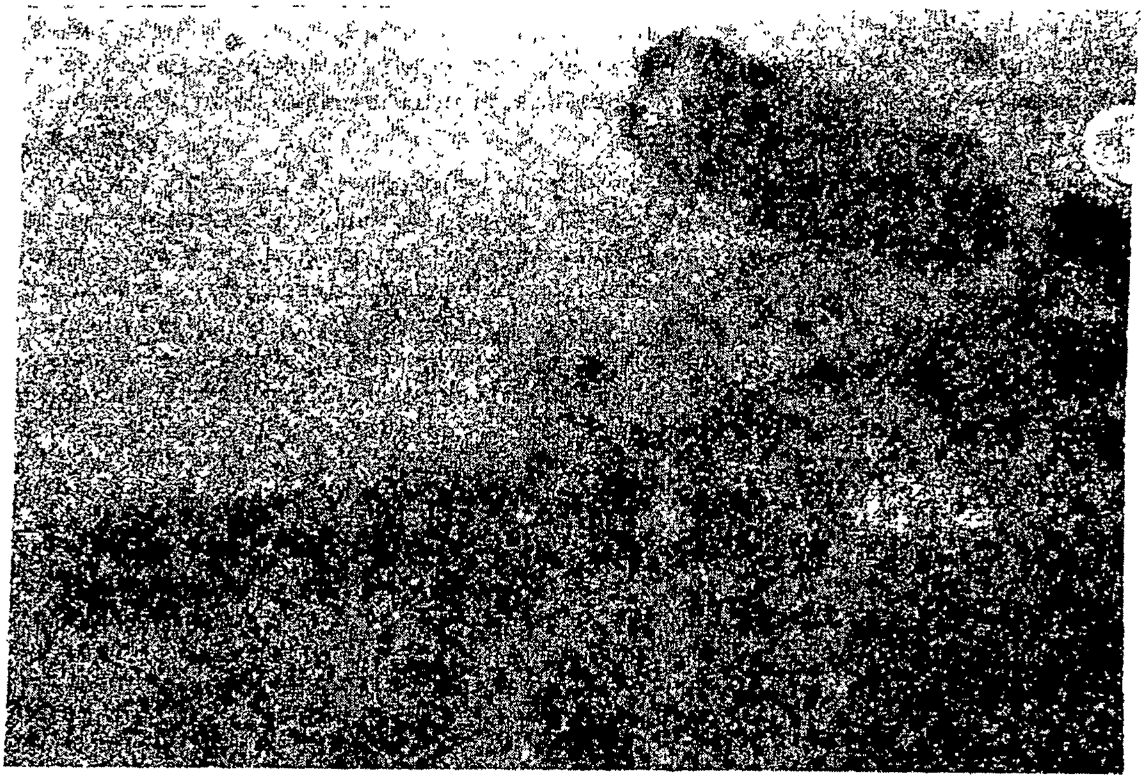

Fig. 1.1. A fossil of a marine bacterium. The earliest trace of life has been found in the rock about 3.5 billion years old.

The whole universe including life and environment of the earth is governed by numerous fundamental scientific laws. These physical, chemical and biological laws and principles have not been created by the scientists, they were already there. By following an explicit methodology scientists have just discovered a small fraction of those from the bosom of nature. Without paying any heed to their intricate role in nature, these discoveries are largely being used for earning immediate benefits with little consideration of their harmful side effects or long-term hazardous consequences which create numerous unresolved problems in the society. We are often using science without having a proper scientific temperament which may be the cause for most of the problems of our environment. Some times individuals act in ways that promote their own short-term interests which more often conflicts directly or indirectly with long-term environmental interests.

Most of the environmental problems are, therefore, exclusively man-made. The major problems of the environment which have now been created can be divided into five main categories : (i) Overpopulation, (ii) Pollution, (iii) Global environmental changes, (iv) Depletion of natural resources, (v) War and insurgency.

It is of utmost interest to recall how these crucial problems have been tackled in nature since long. Controlling the population of a species is one of the foremost principles of the strategy of survival. Most species of plants and animals possess an infinite capacity to multiply, but their populations are not increasing by leaps and bounds, a very significant fact that was observed by Charles Darwin about one and a half century ago. In fact, the population growth rate of many species of plants and animals is much higher than that of man. Bacteria can double their population just within 20 minutes. There are numerous natural constraints for controlling population effectively, none of the species in nature can maintain their population growth steadily for a long time.

Experts consider that it is not the human population size but its steady growth rate maintained since the last two centuries that poses a serious threat to the economic growth through rapid depletion of natural resources of the world. At present, the annual growth rate of population in India is about 2.1% (doubling time of population is 35 years), in Europe it is only 0.3%, and the world average is 0.7%. Even 1% annual growth of population, if it is maintained steadily for a long time, should be considered as abnormally high and cannot be balanced with the carrying capacity of world. In an essay on food and world population written in 1969, S. Brody[1] has given an interesting example : "let us assume that Adam and Eve set up housekeeping 5300 years ago, and that the population increased at 1 percent per year. In 5300 years, the population P, would number $P = 2e^{0.01 \times 5300} = 2.0 \times 10^{23}$ individuals, weighing (at 100 lb per person) 2.0×10^{25} lb, equal to the weight of the entire earth itself." This is a good arithmetical proof that the present steady growth rate of human population is not sustainable i.e., cannot be maintained indefinitely, it has to be checked by all means, otherwise harsh natural methods would operate to reduce it through mass starvation, disease, violence and premature death.

Plants and animals not only control their own number but also maintain a definite ratio between themselves. Animals are dependent on green plants; therefore in a particular environment, the number of green plants must be much higher than that of animals. Of the total amount of solar energy actually trapped and used by the green plants about 80% is consumed by the plants themselves, a lot of energy is consumed by microbes. Of 100 parts of trapped solar energy utilized by plants only a meagre fraction is available to animals.

Man himself is very selective in food habit, he consumes only a few plant species for his food, and he seldom consumes the entire plant but only the grains or fruits. So, in comparison with other herbivores, much more green area would be needed for his survival. But the most paradoxical situation is that every day the number of people on earth is increasing by 0.3 million which requires a corresponding daily increase of green mass many times higher than the newly incorporated human mass, but in reality, the green area of the world is decreasing every day. It reflects the scenario of a losing battle.

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[1] Brody, S. 1969, Facts and fallacies of feeding the world population. In the book : The Subversive Science, Essays toward an Ecology of Man. Ed. Paul Shepard & Daniel McKinley. Houghton Mifflin Co. Boston, USA.

[The mass of the earth is equal to 1.318×10^{25} lb (5.98×10^{24} kg)—Editor.]

The five groups of environmental problems, mentioned earlier, are interrelated, for example, to feed the growing population, the agricultural lands have been extended at the expense of forest lands. Natural habitats of many wild species of plants and animals are thereby destroyed affecting the biodiversity of a country. When natural predators and parasites are eliminated outbreaks of harmful insects and diseases become more common. For controlling them various kinds of toxic pesticides have been introduced which pollute the land as well. Chlorine containing pesticide residues remain intact in the soils for a long time. The run-off water from the agricultural land also pollute the water bodies like ponds and canals, rivers and even the oceans.

In nature, the pollution problem is largely managed by recycling process. All the organic excretory products and dead bodies of plants and animals are disintegrated by microbes to simpler compounds and are utilized again by plants. But in modern times, these waste products are being accumulated in such a huge quantity that their natural recycling is almost impossible within a short period. More-over, a large amount of toxic heavy metals, like chromium, cadmium, lead, copper, mercury, arsenic, etc., along with many non-biodegradable compounds, like plastic and other synthetic compounds present in the industrial wastes, makes the situation more complex and difficult. There are at least 70,000 different synthetic compounds present in the environment, and about 2,000 new synthetic compounds have been entering the environment every year. They are present in drugs, fertilizers, pesticides, food additives, dyes, paints, detergents, clothes, plastics, cosmetics, refrigerants, aerosols, cleansing fluids, building materials, etc. Many of them pollute the environment and create serious problems through their bizarre chemical actions. Chlorofluorocarbons (CFCs) are largely used as a refrigerants as well as various other purposes. They deplete the stratospheric ozone layer by stealing an atom of oxygen from the ozone molecule with the help of this chlorine atom, allowing free entry of harmful infrared rays of the sun into the lower atmosphere.

The air is polluted by toxic hydrogen sulphide (H_2S) gas generated from the garbages creating characteristic bad smell in the locality. The air is also polluted by the smoke from burning of fossil fuels (coal, petroleum, diesel, kerosene) as well as fuel-woods. This smoke contains sulphur dioxide, nitrogen oxides, carbon monoxide and coal soots which are hazardous to health, it also contains carbon dioxide which is not toxic at the existing low concentration and utilized by the green plants for photosynthesis, but its concentration is on the rise in the atmosphere creating global warming or greenhouse effect.

These coal, petroleum, diesel, kerosene, minerals and metals of the mines are our natural resources. Their total reserves are rapidly depleting with ever increasing exploitation without replenishment, so they are called nonrenewable resources. On the other hand, renewable natural resources like water, air,soils, plants and animals are also suffering from rapid degradation, their wholesome qualities and natural distributions have been altered by man.

In the history of mankind, such changes never happened before. Hence, they pose a serious threat to the viability of the environment.

Intra-specific war is very rare among animals except in human. Other species struggle to protect their territories, their own lives, lives of their siblings but seldom engage in mass-killings of their own species. The meaning of the 'struggle' and 'war' is not the same. Wars and insurgencies lead to the depletion of all kinds of natural resources, including valuable lives and economic stability of the country, by far more extreme degrees than any other man-made environmental disruption. But even in the absence of actual war, the cost of maintaining standing army and armaments is enormous and it becomes the principal cause of resource depletion.

Experts indicate that war is not an inherited or inborn tendency in man but a product of his culture. All evolutionary changes take place because the changes are of advantage in promoting the survival of the species. A drive towards killing members of the same species cannot be a part of the normal process of evolution because it is so obviously a disadvantage to the species.

On the other hand, if we follow the history of evolutionary course of life extending through 3.5 billion (350 crore) years we would find that its basic format has been evolved and is still operating on interdependence, mutual coordination and active cooperation. A design of eternal harmony has been achieved through numerous complex chemical, physical and biological reactions using all the biotic and abiotic components of the environment. If we look at the working principle of a microscopic plant or animal cell, we would find that each and every tiny component of the cell is working jointly in an amazing coordination utilizing abiotic components of its surroundings to achieve certain results which keep the cell alive. The body parts or organs of a plant or an animal, e.g. stem, root, leaf, or heart, stomach, kidney, brain, etc., composed of those tiny cells are also working following the same format, — by mutual help and coordination they perform their respective jobs, so they remain alive and sustain the whole organism. In an ecosystem also, all organisms — plants and animals including human beings, are to follow the same strategy of mutual help and coordination to sustain their individual as well as collective existence on this earth. Perhaps this is the basic truth which deserves far more importance and appreciation for our own survival. Present man (*Homo sapiens*) evolved about 0.1 million (one lakh) years ago and he did follow the same principle for about 99% of the time of his existence. If they had been engaged in intra-specific wars since their origin, most probably, the human speices would have been extinct by this time.

1.1.6. Objective, utility and compulsion of environmental studies

The major objective of the environmental studies as reflected from the earlier discussion is to perpetuate a sustainable environment on an infinite time scale so that human population can continue to exist for an indefinite period of time keeping natural relationship with other life-forms and enjoying sound health and high standard of living.

Environmental studies impart adequate knowledge about philosophy, genesis and consequences of local and global environmental problems with necessary know-how for their abatement and control. It also helps the people to identify their own role in the environment and provides them with adequate knowledge to adjust themselves with the limitation of natural resources and conditions avoiding long-term disasters. It also kindles the survival instinct of the people and inspires them to launch or participate in various environmental protection programmes at the state, national and global level.

Environmental studies encompass a large number of disciplines. It relies on botany, zoology, physiology as well as geography, geology, geophysics and meteorology to describe the biological and physical nature of the environment we live in. It is related to philosophy, ethics, psychology, anthropology, demography, archaeology, economics and political science to know how people function, separately and in a group. And finally, it tries to fit these information into a format of ecology offering a total holistic knowledge about the environment, for sustaining life on earth on an infinite time scale.

In our society environmental problems are comparatively of recent origin and these have been generated in such a quick succession that we have yet to acquire adequate knowledge and develop a proper ethical approach to counter these problems effectively. The problems are not possible to be dealt with by scientists alone. Every individual of the country has a role to keep the environment clean, viable and flourishing. The locus of generation of most of the environmental problems is not the machine but it is in the mind of the people. It is the mind that takes all kinds of decision before putting them into practice. Hence, proper education and articulation of mind is primarily necessary for abatement of the problems at the very roots. All these considerations indicate the compulsion of the environmental studies for the sake of our survival.

1.2. Non-anthropogenic and anthropogenic changes in environment: natural and man-made disasters

1.2.1 Natural changes

The earth's environment is not constant, it is ever changing. The environment of the earth has been fluctuating since its creation and, no doubt, it will continue that way in future for an indefinite period of time. When life evolved there was no oxygen in the atmosphere, it was full of carbon dioxide and other gases including water vapour. The earliest life-form was anaerobic, i.e., it used to survive imbibing oxygen not from the air but from other chemical compounds. Such primitive climate changed very slowly, it took over a couple of billions of years to accumulate enough oxygen in the atmosphere which helped the evolution of aerobic organisms. This oxygen was generated from splitting of water molecule by photosynthetic process of green plants, hydrogen of the water molecule was utilized for synthesis of glucose releasing the oxygen into the atmosphere. Virtually, most of the oxygen in the atmosphere today has come from water through the photosynthetic activities of green plants. Such change is non-anthropogenic, i.e., not man-made but it altered the chemical composition of the air radically which triggered a series of other changes in the environment. From this atmospheric oxygen ozone gas was generated which made possible the formation of the protective umbrella of ozone layer at the upper atmosphere called stratosphere. This ozone layer prevents much of the sun's ultraviolet radiation from reaching the earth's surface. This ultraviolet radiation damages living things. The earliest living organisms lived in the ocean, the depth of the ocean-water protected their lives from the harmful effect of ultraviolet radiation.The formation of ozone layer permitted these organisms to thrive on the land as well as in the ocean. This change of environment directly influenced the organic evolutionary processes, a large number of terrestrial and aquatic plant and animal species were evolved which enriched the biodiversity of all primitive continents.

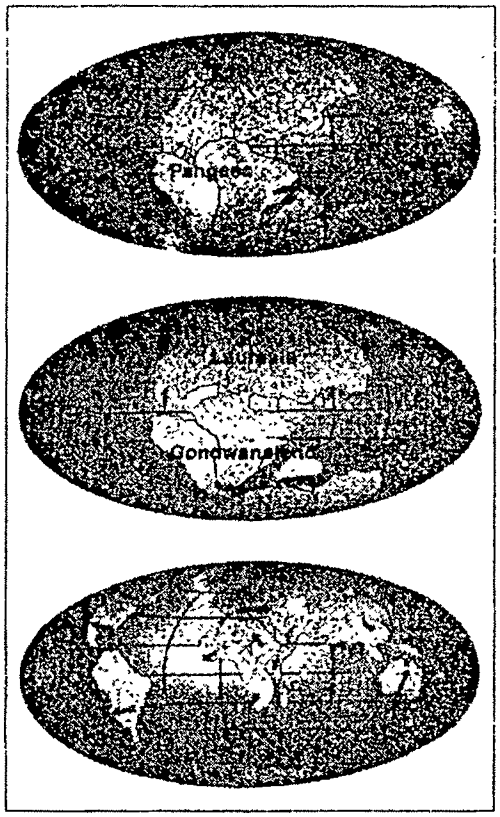


Fig. 1.2. Continental drifting. All the continents were once joined together forming a single mass called 'Pangaea' (top), at later period they drifted apart very slowly forming two major groups 'Laurasia' and 'Gondowanaland' (middle). Some 50 million years ago, the world's highest mountain the Himalayas were formed when the Indian plate collided with the Asian plate (bottom). Such changes will continue in future.

The most striking feature of those continents was that they were not stationary, they were slowly drifting apart. The entire outer shell of the earth is made up of a number of huge tectonic plates which float on the fluid core of the earth. German meteorologist Alfred Lothar

Wegener stated that all the continents were once joined together forming a single landmass, which he named 'Pangaea', the Greek word for 'all land', at later periods they drifted apart very slowly, the movement he called 'continental drift'. Further studies reveal that there are altogether seven major and twenty minor tectonic plates, their average thickness is about 100 km and the area of the largest one is about 100 million sq km.

The continents have drifted for at least 2500 million (250 crore) years, and continue to move at an annual rate of 20 to 75 mm. During the movement, part of a continent can split from the rest, in a process called rifting. Such a rift created the Atlantic Ocean, 175 million (17.5 crore) years ago. The Red Sea was formed in this way, as part of a rift that still goes on. Siberia, too, has an active rift system, which created Lake Baikal. When plates move away in one place, they converge in others. And when they collide, the impact can be catastrophic, crumpling mountain ranges, causing great earthquakes, opening up of volcanoes and ocean trenches. Some fifty million years ago, the world's highest mountain, our Himalayas, were formed when the Indian plate collided with the Asian. Once upon a time, the Sahara desert of Africa was situated near the South Pole, wherefrom it moved to the equatorial region. Certain rocks which are only found under the snow in polar region, have been discovered under the hot sand-bed of Sahara.

Such drifting of continents made profound changes both in abiotic and biotic components of the ancient environment. The process is still going on very slowly. Plants and animals had enough time to adapt themselves to such changed environment, those that could not, were simply replaced by newly evolved species suitable to thrive in the changed environment.

The earth's environment also witnessed drastic changes in average temperature of the earth surface creating the *Ice Ages.* The temperature appears to have fluctuated between two

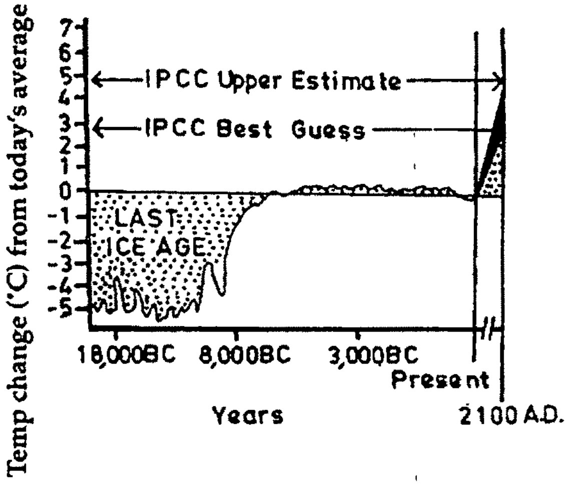


Fig. 1.3. Changes of global average temperature from 18,000 B.C. to 2100 A.D. A fall of only 4 to 5°C from today average brought about the ice age 20,000 years ago, hence one can imagine what drastic changes would occur when temperature will increase 3 to 5°C due to global warming. Note how temperature rose quickly around 8,000 B.C. as the world emerged from the last ice age. The average temperature rise predicted beyond 1990 by the IPCC (Intergovernmental Panel on Climatic Change) scientists is many times faster than theat past warming periods. The gray peak is the IPCC 'best guess' by 2100. The black peak is the upper range of the estimates from the IPCC models.

relatively stable states about 35 times during the earth's history, caused perhaps by the wobble (unequal rocking) of the earth on its axis and variations in the sun's activity. The peak of the last Ice Age was only about 20,000 years ago; human species observed it. A vast sheet of ice advanced south from North Pole, covering Canada, Greenland, Siberia, Scandinavia and most of Britain including the North Sea. When the ice retreated vast quantities of cold water flooded into the Atlantic, disrupting the ocean currents. Probably, we are still in the spell of the last Ice Age as the ice has not yet retreated from the polar regions. Gigantic woolly mammoth, sabre toothed tiger, certain species of sloth and some other species of plants and animals disappeared, but at the same time many new species evolved, so biodiversity was not permanently damaged.

1.2.1.1. Succession

Environment also may be changed by a natural process called *succession*. It occurs when the land is initially lifeless, may be it is a new island rising from the sea, or a solid bed of rock created from the volcanic eruption. The environment may be hot and dry. But after some time, this area will be invaded successively by different communities of plants and animals. The area will be slowly transformed into a woodland and ultimately a dense climax forest may be developed full of microbes, insects, birds and wild animals. In course of time, a once hot, lifeless, dry environment may be changed into a moist, cool forested land. The formation of vegetation from initially lifeless substratum is called ***primary succession*** and those from denuded land with little or no vegetation left is called ***secondary succession***.

The first group of invaders that usually colonize on dry rocks are the lichens. Lichens are a special group of plants, their body is made up of fungi and algae living symbiotically, they do not require soil, they collect water and minerals from the atmosphere. The first layer of soil is built up with their colonies and air-borne dust particles deposited on them on which other groups of plants like mosses, ferns and grasses could grow. Woody plants and big trees come subsequently for developing long-lasting climax vegetation with a few dominant species.

Similarly, stagnant water bodies also slowly transform into dry lands and ultimately give rise to climax forests. Such natural transformation of aquatic environment into a forest-land is called ***hydrosere***, and that from a dry environment is ***xerosere***.

1.1.2. Natural disasters

Enormous changes of environment also have been caused by the natural disasters, e.g., ***cyclone, typhoon, hurricane, tornado, earthquake, volcanic eruption***, etc. within a very short time and more often without serving any notice, the environment is totally devastated, beyond any comprehension, inflicting huge damages on lives and properties.

Cyclone, typhoon and hurricane are synonyms for the same weather phenomenon. Storms that arise in the Indian Ocean and cause extensive flooding and damage in the Indian subcontinent including Sri Lanka and Myanmar are called cyclones. Those in the Pacific Ocean that threaten southeast Asia are typhoons, and those in the North Atlantic Ocean that batter the Caribbean and southeastern USA are hurricanes.

Over very warm areas of ocean, warm, moist air starts rising so fast that it creates a region of intense low pressure beneath it, pulling more warm air in from the surroundings. The phenomenon develops into a vast spiraling weather system — a cyclone. The spirals twist anti-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere. They tend to drift at a very high speed, in case of super cyclone they can reach the speed of over 250 km/h, and the whole weather system may be 800 km across. Dense cumulonimbus clouds release torrential rain and the winds whip up high waves on the surface of the ocean beneath the cyclone. The intense low pressure can temporarily raise the sea-level by as high as 8m (25 ft) to what is known as storm surge, which can cause devastating floods along the coastal region. In the middle region of the cyclonic spiral known as the *eye* — the air can be clear and deceptively still. Cyclonic weather can continue for several days. Instead of low pressure, intense high pressure also can give rise to a cyclonic storm; it is called ***anti-cyclone***.

Dense afforestation on the coastal regions can reduce the impact of cyclone on the urban areas to a significant degree. The presence of ***mangroves of Sundarbans*** at the south of West Bengal thus lends some help in this way bearing the brunt of the impact themselves. Correct weather-forecast is also helpful for partial reduction of cyclonic damages.

Tornadoes are also caused by rising spiral of air but they are on a smaller scale affecting a smaller area with much shorter duration than those of cyclones. But they can be just as devastating as cyclones, up-rooting big trees, tearing off roofs, lifting cattle, cars, people and sucking up almost any thing on their path. Timely forecast can stop much of the damages they do, but the time interval between the alarm and their appearance is so short that often it becomes use-

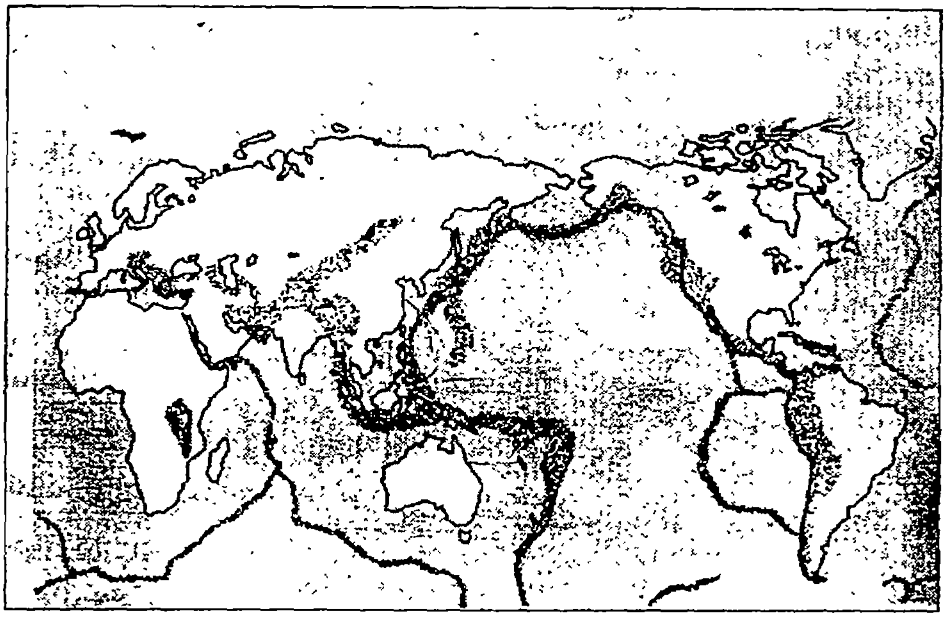


Fig. 1.4. Most earthquakes occur in clearly defined zones (shaded) that girdle the earth. A map of these regions outlines the major tectonic plates of the earth's crust which more and often collide.

less, more over, their exact path of movement is rather difficult to ascertain. Tornadoes are more common in certain parts of the world, e.g., Mexico, southern states of USA, etc.

Frequency of earthquake is very high, almost unbelievable, the figure is approximately one hundred per hour (100/h); every hour seismologists may record 100 earthquakes. But most of them are of low magnitudes and 90% of them are restricted to earthquake-prone regions that almost encircles the Pacific Ocean, and most of the others in a band stretching from Spain, Turkey and the Northern Mediterranean, through the Himalayas and Indonesia. The two zones meet near New Guinea. The earth's outer layer is broken into seven huge tectonic plates and squeezed among them are some twenty smaller ones. The plates move independently over the ***asthenosphere***, a partially molten mass of the upper mantle. The plates often converge and collide, frequently one plate slides beneath another releasing tremendous amount of energy in the form of ***seismic waves*** that run through the earth shaking the ground often with a tremendous destructive force.

American seismologist Charles Richter devised the ***Richter Scale*** for measuring the amplitude of seismic waves on a logarithmic scale, thus magnitude of 7 Richter is 10 times bigger than that of 6 Richter. The magnitude of earthquake of 1 Richter could be detected only by seismograph, magnitude 2 is about the smallest that humans can detect. In 1999, the earthquake of Izmit, Turkey that killed 15,000 people, was 6.7 on the Richter scale. The largest known earthquake that struck Quito, Ecuador in South America, was 8.9 on the Richter scale. It generated as much force as 125 million tonnes of TNT, which is equivalent to the explosive power of 10,000 Hiroshima type atomic bombs.

It is not possible to perdict earthquake, but various precautionary measures have usually been arranged in earthquake prone regions. In Japan wooden houses were constructed; at present, newer architectural designs are being used to resist the tremor of earthquakes.

Volcanoes sometimes explode with devastating power, erupting molten lava, silicate dust and sulphuric acid into the atmosphere. When Mt. Pinatubo, in the Philippines, erupted in 1991, it increased the dust content of the atmosphere to at least 60 times more than the usual amount and warmed the upper atmosphere by 3°C for several months. Today, there are more than 600 active volcanoes and numerous dormant and dead ones mostly located along the boundaries between tectonic plates that make up the earth's shell. Around the Pacific Ocean, volcanoes are situated forming a ring called the ***ring of fire***. In the past,great geological changes were induced by volcanic eruptions. Hawaiian islands came into existence from the molten lava. Sixty-five million years ago the landmass of western India was formed from the basalt flow of volcanic eruption. No one can prevent volcanic eruption, but some times prediction can be made from the sound of tremors and changes of quantity, chemical nature and temperature of the gases released from the dormant volcanoes, that helps mass migration.

1.2.3. Anthropogenic changes in environment

No species on earth has made such a radical and deleterious change of the environment as that made by ***Homo sapiens***. These changes even could be seen from the space : city lights and gas flares by night, and unearthly straight lines of irrigation canals, big dams like 'Three Gorges' in China, vast agricultural lands by day.

The basic components of the environment have been changed. The earth's atmosphere is now changing more rapidly than any time in the past. In the last 150 years there has been a 25 percent increase in carbon dioxide and 100 percent increase in methane in the atmosphere, largely due to burning of fuel woods, fossil fuels, expansion of agriculture and deforestation. Methane gas is generated by the methanogenic bacteria through decomposition of farm-manure. Expansion of farming increases the production of methane. Destruction of forest-lands destroys the sink for elimination of carbon dioxide, these two are greenhouse gases. Over the last 100 years, the world has warmed up by an average of 0.5°C, as these greenhouse gases trap the solar heat within the atmosphere. Scientists predict a continued warming of 0.2°C a decade. Quality of the air also has been changed by the presence of numerous newly synthesized toxic chemical compounds either in gaseous forms or as suspended particulate matters (SPM), e.g., chloroflurocarbons (CFCs), halone (these two gases are depleting the ozone layer in the stratosphere), DDT, PCB, aldrin, lindane, asbestos fibres and numerous other compounds containing toxic heavy metals. These are creating various insurmountable problems for all life-forms.

In the past 500 years, especially the last 100 years, the destruction of forests for expansion of agriculture and roads, towns, factories has greatly increased. This development has destroyed the habitats that many plants and animals need to survive. Tropical rain forests cover only about 7 percent of the earth's surface, yet they house about three quarters of all species. Today, these forests are being destroyed at an alarming rate. The depletion rate of forested area of the world is now about 2 percent per year which indicates that after 50 years, perhaps there would be no forests left except reserve forests. India had forests cover of 80 percent around 3000 B.C. which is now reduced to about 21 percent. To maintain the ecological balance at healthy constant level at least 33 percent forest cover (one-third of the total land area) is essential.

Progressive deterioration of environment has led to the extinction of numerous species of plants and animals all over the world. Most of these species are becoming extinct without evolving their more adaptive forms. Fossil records indicate that in the past, the average rate of formation of new species through evolution has been slightly greater than the rate of extinction. Hence, the number of species on the earth has gradually increased over time. But today, the impact due to man-made changes of environment is so abrupt and intense that species are becoming extinct without any replacement, thus an irreversible damage is being inflicted to the living resources of the earth, its biodiversity is definitely on the decline.

Qualities of water and soils also have been altered due to human activities of varied nature. Farming practices result in the release of nitrates and phosphates from fertilizers and animal wastes into ponds, lakes and rivers, adding to sewage already released into rivers and seas causing blooms (excessive growth) of algae which subsequently deplete the oxygen of water (eutrophication) causing harmful effect on aquatic life with rising deterioration of their environment. Millions of tonnes of top-soils are lost from crop fields each year eroded by wind and water. Irrigation is lowering the ground-water table and creating serious crisis in the net usable water reserve of the world.

Mining and industries release huge amount of synthetic products and waste matters that pollute the soils, water and air. Toxic as well as non-biodegradable compounds like insecticides, herbicides, drugs, plastics, nylons, chemicals containing mercury, lead, cadmium, chromium, copper, zinc, arsenic and radio-active nuclear wastes are the major culprits. They have reached everywhere including oceans and most of them get entry into the body of all organisms through the food chain seriously posing the problem of survival.

Man most probably evolved 100,000 years ago. He started farming about 10,000 years ago, the impact of which initiated the changes of his environment. But almost all the changes, described here, have been developed during the span of last 200 years, when man gained sufficient knowledge to control epidemics, premature death, infant mortality and acquired adequate technology to exploit natural resources. In the past the earth displayed a remarkable resilience, globally if not locally; today, an exploding population that demands ever increasing affluence may be pushing the man to dig out and spend up earth's resources to its last limit without considering ultimate consequences.

1.2.4. Man-made disasters

Man-made environmental catastrophies include wars, explosions, accidental release of poisonous chemicals or radioactive materials etc. At the same time, very slow and subtle man-made changes in the environment also bring about disasters in the long run. Burning of fossil fuels and deforestation result in global warming or greenhouse effect. Use of chloroflurocarbons and release of oxides of nitrogen gas by supersonic transport would cause ozone hole by depletion of ozone layer. Day-to-day activities of the people of the world perhaps are responsible for such long-term consequences. These are global problems which require international cooperation for abatement.

There are many examples of man-made disasters; only two examples, both of which became major environmental issues and drew world attention to the perils of environmental degradation are cited here.

1.2.4.1. Bhopal gas disaster

On December 3, 1984, in Bhopal, India, world's most disastrous single instance of gas pollution accident occurred when about 36 tonnes of toxic methyl isocyanate (MIC) escaped in a cloud of mist and vapour from a large storage tank belonging to the American multinational corporation, Union Carbide, which killed about 2,500 people, permanently disabled 17,000 and injured 200,000 people. The toxic gas is used to produce a common pesticide sevin. The need for sevin comes from increased agricultural production to feed the growing population.

The human errors, negligence and mechanical faults which are found related to the accident are as follows : (a) The plant was located too close to a major centre of population. (b) Union Carbide stored very large quantity of methyl isocyanate (MIC). (c) The accident started when a large amount of water was introduced in the MIC tank, how it was possible not yet known. (d) Safety mechanism did not work. The man on duty tried to turn on the scrubber to check the escape of poisonous gas but neglected to activate the circulation pump. The flare could not be used because it had been removed for maintenance work. (e) Medical aid was unavailable during the accident. (f) People had not the faintest idea what they should do during such a crisis.

Many such accidents, as well as the magnitude of disasters, can be controlled if proper precautionary measures are taken before hand.

1.2.4.2. Chernobyl nuclear plant disaster

World's most disastrous nuclear plant accident occurred on April 28, 1986 at Chernobyl in the erstwhile Soviet Union. Two subsequent gas explosions in a graphite-controlled, water-cooled reactor at the nuclear plant blew off the roof of the power house building and set the graphite on fire. The accident occurred when the engineers were performing an unauthorized safety experiment by turning off most of the reactor's automatic safety system. Fire broke out during the explosion, 31 people died due to direct exposure of radiation. About 100,000 people who lived near the nuclear plant had to migrate elsewhere. Radioactive particles carried down by the air current scattered over many hundred kilometres round the nuclear plant. Air, water and soils were highly polluted with nuclear wastes. These entered into the food chain. In the following year, a large number of cattle gave birth to deformed calves, such phenomenon continued for several years. Medical experts estimate that near about 100,000 people will die of cancer over the next 70 years caused by the radiation exposure from Chernobyl.

Further investigation revealed that the design of the nuclear plant was faulty. The accident was, however, caused largely by operator's errors. Plant design can be rectified, even it can be improved, but total elimination of human error is almost impossible to achieve.

1.2.5. Land use patterns : agriculture, housing, urbanization, environment *vis-a-vis* economic development : human concern about environment.

The time of origin of our own species *Homo sapiens* cannot be pinpointed very precisely. Most possibly humans appeared about 100,000 years ago evolved from ***Homo erectus***. In the beginning they were hunter-gatherers, people who obtained food by collecting plants and killing animals including fishes and oysters. But their main source of food was plant materials, e.g., fruits, nuts, roots, seeds, berries, leaves, young buds, inflorescence, etc. Most early hunter-gatherers were nomadic moving from place to place in groups according to availability of food. For about 90,000 years they did follow the same lifestyle, i.e., 90% of the time of human history man was that of the hunter-gatherer.

Most probably, 10 to 12 thousand years ago humans slowly learnt how to grow plants and domesticate animals and also discovered herbal medicines and other natural resources for betterment of health and housekeeping. Primitive type of cultivation perhaps originated simultaneously at several places in the world. As compared to hunter-gatherers, ancient farmers had to lend much longer time and harder labour for procuring food, they also had to face drought, flood, insect-pests and other natural calamities, yet agriculture gained popularity in primitive societies because it was possible to obtain much more food by farming than by hunting and gathering. Manual labour of every one was not compulsory, a small number of people could produce sufficient food for a large group, others were freed to become potters, painters, builders, teachers, etc. and a division of labour grew up within the group. Value of land and properties gained recognition. People used to settle in villages and largely became dependent on farming and landed properties.

Development of agriculture has been considered as a great revolution in human history. However, the genesis of most of the environmental problems can be traced back to agricultural practices, for examples : depletion of virgin forests with destruction of species habitats, extinction of large number of plants and animals, reduction of soil fertility due to increased soil erosion, pollution of air, water and soils, acceleration of human population, etc. Our objective, however, is not to discredit agriculture but to find out a sustainable system for maintaining the sound and healthy growth of human society.

Demographers have concluded that the primitive cultures experienced very low growth rate. Population of hunters and gatherers was stable over a long period of time. As agriculture became increasingly efficient, people used to get more food, more leisure and women began to bear more children, and human populaton started to increase. The population in between 10,000 BC and 100 AD was less than a billion and it was largely a result of the increasing birth rate that coincided with the progress in agriculture. But even during this period the human population did not increase steadily. Periodic decline of population occurred due to the recurrence of famine, epidemic disease, natural disaster, human warfare, etc. Hence, in the ancient period, the human population did follow a wavy pattern of growth curve comparable to that of wild plants and animals in nature.

With the growth of population and advancement of human culture and lifestyle, towns and cities came into existence. These human settlements were mostly built up along the bank of rivers for easy access to water and transport facilities. Along the bank of the rivers, Tigris and Euphrates, the first cities arose about 6000 years ago. In India along the bank of Ganga ancient cities Varanasi, Haridwar, Pataliputra (Patna), Nabadwip (Nadia), etc., were developed. But urban population was thin, most people lived in villages. Even in Europe, in 1800 AD only 2.2% of population lived in cities and no European city had 1 million inhabitants.

The basic difference in environment between the city and outside lies in the fact that the urban environment is not viable or in other words not self-sustainable. Urban people are totally dependent on outside natural environment for their food, clothing, building material, coal, oil, etc. If the demand for those life-supporting materials becomes too high and exceeds the bearing capacity (production potential) of the surrounding natural environment the crisis for survival appears in both the places.

During the span of last two hundred years a spectacular change in the urban environment occurred. With the discovery of scientific principles through proper observation and experimentation, with the development of newer technologies, the exploitations of natural resources, e.g., fossil fuels such as coal, petroleum, and natural gas and various metals from the mines increased thousand-folds. Mass collection of raw materials were made from different areas even from remote parts of the world. Cities became the nerve centres for manufacturing and trading of numerous finished products. A large number of people moved to the cities to find good wages, better lifestyle, better medical and educational facilities and urban regions became centres for art, culture and social activities of all kinds. In 1900, only 12 cities of the world had populations of more than 1 million, but in 1985, a total of 230 cities were there with a million or more inhabitants. About 40% of inhabitants of the world are now living in urban areas. These changes have been brought about by the Industrial Revolution which was initiated in Europe, more precisely in England in the 18th century.

1.2.5.1. Industrial revolution

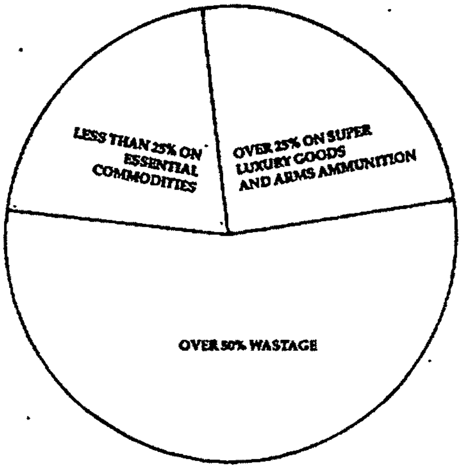
The name was first given by Friedrich Engels in 1844, to describe the radical changes that took place in England during 1760-1840 to transform an agricultural country into a predominantly industrial one. It started with the introduction of mechanization in textile industry with subsequent major advancement in mining, transport and ship-building and industrial organization. It was based on Britain's rich mineral resources, particularly coal and iron ore. James Watt, a Scottish engineer in 1785 made important improvements to Newcomen's steam-engine by inventing a separate condenser with the application of Black's discoveries on latent heat. With the use of steam-engine as power, industries proliferated and the great industrial (as well as highly polluted) cities of Manchester, Newcastle, Birmingham and Glasgow developed. Britain became supreme in constructional ironwork. All over the world railways, canals, bridges and ships were built and great advances were made on practical application of scientific principles. Aided by colonial exploitation Britain became the most prosperous country in the world. The new industrial capitalists began to replace the country's old land-lords as the ruling class. However, the massive accumulation of wealth at one pole of the society was matched at the other by poverty and misery, — child labour, long working hours, low wages, and slums with highly polluted environment, which were the salient negative features of the industrial revolution. It, however, produced related changes in all fields of social life — in politics, science, religion, art, literature and ethics.

1.2.5.2. Environment *vis-a-vis* economic development

Economic development describes changes aimed at improving standard of living of general people of the country, increasing wealth, eradication of poverty, hunger, famine, and spreading of culture and education and augmenting peace and stability of the country which is imperative to all countries and obligatory to a developing country like India. On the other hand, sustainable development, essential for a viable environment, describes changes that do not deplete natural resources and such condition is imperative if the above mentioned developmental activities are to continue for an indefinite period of time. Physical laws indicate that we cannot go on depleting natural resources forever. It is basically a self-destroying process reducing the carrying capacity of the earth towards a catastrophe.

The industrial revolution initiated in 18th century was extended to all other countries in Europe, USA, Canada and Japan, which are now called developed countries. In fact, intense industrialization of those countries was largely responsible for their economic prosperity. During the peirod of rapid economic progress they paid little attention to the environment and numerous problems related to environment were allowed to grow up.

As early as 16th century, during the period of ***Renaissance***, when exploitation of natural resources was initiated, our knowledge in ecological science was almost nil and we took it for granted that the earth's resources were unlimited and could be consumed for ever. In the later period, contrary facts were placed before the policy makers, but they did not pay any heed to it. Only during the latter half of the last century, more precisely, after the United Nations Stockholm Conference on Environment in 1972, people who matters just started talking on ***'sustainable development'***. But meanwhile, irreversible damages had been inflicted on plants, animals, soils, air and water — all life-supporting resources of this planet.



CONSUMPTION OF NATURAL RESOURCES

Fig. 1.5. The total amount of natural resources we use (e.g., water, fuel, minerals, etc.), only less than one-fourth of them is utilized on essential commodities, e.g., food, clothing, housing, medicine, transport, education, sports and cultural activities. Over half of them is simply wasted due to basically inadequate and faulty processes of utilization. Over quarter of them is spent on commodities which are not essential and some of them are even against public health, these are superluxury goods, arms and ammunition, drugs and narcotics etc.

In a true sense, the term 'development' means, wholesome, perpetual development without entailing future complications. But at the same time, we have to realize that if we are going to have sustainable development, we cannot leave the environment totally pristine, there will be some obvious change, some significant impact will be made on the environment. But there is an ample scope to make those changes bearable, even favourable to the life-supporting system of the environment. Now-a-days, ***Environmental Impact Assesment*** has been made compulsory for starting a developmental project. If environmental laws and regulations are properly enforced developmental work can go on with minimum injury to the environment. Lack of ethics and knowledge would also stand against the developmental work. A huge wastage of natural resources can be saved with a sizable dividend if we take some precautions regarding their misuse and abuse. It is a very significant fact that of the total amount of natural resources (like water, energy, minerals, metals, etc.) we use per year only less than one-fourth is being utilized on essential commodities, e.g., food, clothing, housing, medicine, health, transport, education, sports and culutral activities. Over half of the valuable resources are simply wasted due to basically inadequate and faulty methods of utilization producing serious environmental problems. The most efficient diesel engine can convert only 40 percent of the diesel into energy, remaining 60 percent is just wasted creating air pollution. Only 20 percent of irrigation water is utilized by the crop plants, the rest is wasted during transport creating serious water crisis and incurring huge expenditure on construction of more dams. Only 10-15 percent of costly fertilizers is used by crops, the rest is wasted generating algal bloom in water bodies. Less than one percent of solar energy is used jointly by man and green plants, problems of food and fuel would have been solved if only one percent more could be used.

Nearly one-fourth of natural resources is spent on commodities which are not essential and some of them are even against the public health, these are super luxury goods, arms and ammunition, drugs and narcotics, etc. Military spending in the past 25 years absorbed more than the total increase of global productivity. Between 1960 and 1985, the world-wide economic output per person grew by 62%, but military outlay grew by 146% (more than double and amounted to nearly $ 14 trillion). The money obviously comes from depleting natural resources, a cut in our standard of living and from enormous increase in national debts. During formulation of development plan priority should therefore be given to save natural resources from wastage, misuse and over-exploitation.

1.3. Environmental hazards and risks

The earth's environment touches every one. Every human activity, small or large, lighting a match stick or igniting a blast furnace, creates some kind of distrubance of change in the surrounding environment. If such change is of a very high magnitude some time disastrous result may ensue. The lighting of a match stick in the vicinity of an inflammable object may bring about a fire accident, hence there is 'risk factor' when any one deals with inflammable objects, but such a risk factor is almost negligible when one lights a lamp in the house. On the other hand, dealing with blast furnace which contains molten iron at 1000°C is of course a very risky and hazardous job, a slight fault may cause irreversible damage, hence its risk factor is enormous. In the commercial field lists of hazardous chemicals, hazardous machineries, hazardous occupations are available, similarly, lists of eco-friendly chemicals, eco-friendly chemical processes, which apparently do not produce any problem in the long run, can be obtained. Earlier, we have discussed the Bhopal gas disaster and Chernobyl nuclear plant disaster, in both the cases the machineries and occupations were very risky and hazardous. But it was revealed, after the accidents, that in every turning point some gross mistake, negligence and wrong decisions (not befitting the inherent risk factor) were taken. Prior calcualtion of the risk factor of an environment-related operation is very essential, it can avert many a disaster of far-reaching consequences. In 1955, at Minamata Bay in Japan a plastic paint factory started releasing mercury containing effluents into the water of Minamata Bay, the whole food-chain of the aquatic ecosystem of the region was polluted, quite a large number of local fishermen died due to Minamata disease, a special name given to mercury poisoning. After losing a long legal battle, the factory owner had to pay a huge sum as a compensation. Such loss of lives and wealth could easily be averted if prior risk assessments were performed and implementation of recommendations ensured.

Economists often point out that it is worth spending vast sums to prevent environmental degradation. Cost-benefit analysis shows that a huge loss is incurred on such degradation. If we assess the cost of air pollution damages, we have to count the costs to human health, to plants and animals, to damages to properties. In West Germany as in many other countries, a large number of trees die of air pollution, the value of trees killed worldwide must be enormous. Value of a tree should be calculated not only on the basis of dead weight and quality of the timber but also on the other benefits derived from a tree, i.e., amount of organic matters it contributes, elimination of carbon dioxide and enrichment of air with oxygen, recycling of water, etc. As we discover more and more indirect costs of pollution, we find that pollution costs us enormous sums. Economists are convinced that much greater investment in the control of environmental pollution would pay larger dividends.

Recurrence of very slow and subtle changes in environment caused by us also initiate profound changes and may produce global problems, —burning of fossil fuels and use of CFCs are the best examples. In these cases mistakes are committed not by a few people but by a large mass and the whole world has to suffer. Sometimes, such mistakes committed by a few countries create an unresolved problem for all. Each and every inhabitant of the world, therefore, has to think of the risk factors when he deals with the environment. He has to play a precise role in keeping his own environment clean and viable, he is to act locally while thinking globally. A full scale operation of the international action programme with active participation of all the nations is essential for achieving a tangible result, there is no easy and quick solution in this matter.

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CHAPTER II

NATURE AND NATURAL PROCESSES

We live on the earth's surface. Not only the human, but also all living species get their sustenance from mother earth. So earth is not simply beautiful — it elegantly displays prerequisite conditions for living of all species. Our earth is a planet in the solar system. Sun in the solar system is the source of all energy. It is not exactly known whether any other planet bears the sign of life. In that context the earth is unique and bountiful of living organisms as nature is endowed with favourable conditions for biotic regeneration.

For our sustenance it is necessary to understand nature and natural processes. In understanding nature, firstly we must gain knowledge of the earth itself—how it has evolved and under what conditions.

2.1. Planet earth — origin and evolution

As mentioned the earth is a planet and a small part of the solar system. The solar system again belongs to the universe. The universe is defined as the total of all the matter, energy and space. So in the universe we observe vast space along with many galaxies and constellations. The galaxies and constellations contain innumerable number of stars, planets and meteorites. A galaxy is an island of matter in space — where tremendous collection of gas, dust and millions or billions of stars are present. The galaxy we live in is known as the *Milky Way*. It has a disc like shape and the earth is located nearly halfway out from the centre. As we look toward or away from the centre or in any direction in the plane of that disk we find many stars and much dust and gas. For better understanding of the origin of earth as a planet it is desirable to have a glimpse of the celestial bodies.

2.1.1. Evolution of stars

Stars initiate with the collapsing of gases of clouds in interstellar spaces and turn to be stars when nuclear fusion starts in their interiors, fusing hydrogen into helium. In the type of nuclear fusion that occurs inside the sun and most other stars four hydrogen nuclei fuse to become one helium nucleus. During their active period energy from the fusion creates a pressure that pushes outward, balancing the inward force of gravity. All stars have life cycles — they are born and they die. Usually the hottest stars, much hotter than the sun have shorter lifetime as they spend their fuel at a furious pace, become cool or eventually die within 100,000 years. Stars similar to sun can survive for about 10 billion (10,000,000) years. Stars cooler than the sun can continue much longer, even 50 billion years or more.

When the stars spend all the hydrogen in their interiors, they can no longer fuse hydrogen into helium. As a result they cannot offset gravity and their interiors begin to contract. During the contraction energy is released and the outer layers are pushed out. These outer layers become larger and cooler, and the stars become ***red giants***. Finally the outer layers of some red giants are disconnected and float outward, having nearly 20 percent of the star's mass out into space. Such expanding shell of gas is known as ***planetary nebula***. Nebulae are the clouds of gas and dust that look hazy to our view. A few nebulae represent shells of gas ejected by dying stars. The escaped nebula appears blue as it shows the inner layers of the star and is hot. Say after 50,000 years or so, the planetary nebula drifts away, and the central star cools. As a result the central star contracts until it is about the size of earth. If a mass less than 1.4 times the mass of the sun is left, the star continues at this stage indefinitely. This stage is called ***white dwarf***. The objects like red giants, nebulae and white dwarfs are actually different stages in the life history of ordinary stars.

After a star becomes a red giant, it grows larger and turns to be a super giant. At that point it may explode totally, giving birth to a ***supernova***. A supernova is the brightest object in the galaxy. The supernova completely destroys the star, forming heavy elements and then ejecting these elements out into space. When our solar system was formed, the sun and planets contained these heavy elements. It may be presumed that our solar system came into being when a supernova made a cloud of gas and dust that began to collapse. During a supernova explosion, the core of the star can be extremely compressed and collapsed until it is quite small. Stars having 1.4—4 times mass of the sun collapse until they reduce to a quite small size. Most of the stars at that point contain gas of neutrons only, or of smaller particles called ***quarks*** that make up neutrons. The star is then known as a ***neutron star***.

In some cases a mass greater than about 4 times that of the sun exists even after a supernova explosion. Then the collapse of the star is inevitable. Because of its gravity, it becomes more and more compressed. The ***theory of relativity*** suggests that even light will be bent so much by the strong gravity that the light no longer will be able to escape. In fact nothing would escape. The star will turn to be a ***black hole***. Black holes are even fainter than the neutron stars.

2.1.1.1. Sun in the solar system

Most of the stars are observed at night, the sun is only visible during day hours. Sun is the closest star to earth, only 150 million km away. The light from sun takes only 8.3 minutes to reach the earth's surface, whereas the nearest distance of any other star is more than 4 light years. The sun like all other stars is a ball of hot gas. It has a very hot core and relatively less hot atmosphere. The light and heat emitted from the surface of sun provide energy to the earth's surface. The sun is the sole determinant of the existence of all species on earth.

Energy : The energy is created at the core of the sun's interior by the process of nuclear fusion in which hydrogen is converted to helium. Each helium atom that results from fusion, has less mass (0.7%) than the sum of four hydrogen atoms. Albert Einstein's equation, $E = mc^2$, explains that the little bit of disappeared mass will be transformed on multiplication by c^2, (the square of the velocity of light) into a large amount of energy. The sun is a good example of a nuclear fusion reactor that humans have not yet been able to master for power generation.

Photosphere : The solar surface is called the ***photosphere.*** The term has been derived from the Greek word *photo,* meaning light. The surface of the sun has, in general, uniform brightness, being slighly darker along its edges. Even there are few darker areas on its surface. These dark areas are relatively cooler regions of the solar surface and are called ***sunspots.*** The sunspots cycle (11-year cycle) significantly influences the global climate.

2.1.2. Origin of the earth

The origin of earth is still debated. The earlier concepts that the earth and other planets have their origin from the sun are not accepted now. The origin of the earth is related to the complexities of the universe and formation of stars and nebulae in the universe. The emergence of the theory that the solar system coagulated from a vast cloud of dust has revolutionized our ideas and led to an inquiry into the chemical history of our planet.

Kuiper suggested that the original mass of dust and gas became separated into one portion forming the sun and others forming the planets. Firstly, the primordial dust cloud might have coagulated into ***protoplanets*** composed of ***planetesimals.*** The gases that might have coagulated with the planetesimals would have been driven away later and finally formed the planets. The so called ***terrestrial planets*** — ***Mercury, Venus, Earth*** and ***Mars*** — might have lost their gases. This has been evidenced from the study of transformation and composition of earth's atmosphere. There has been a curious relationship between the atmospheres of the earth and other stars including the sun. Though neon is very rare in earth's atmosphere, it is comparatively abundant in the stars. Neon might have escaped from the earth during very hot period of its inception, together with all of the water and other volatile matter that constituted the atmosphere at that time. The present atmosphere has been created in later periods through the escape of nitrogen, carbon and water from the interior of the earth. Argon is the result of decay of radioactive potassium, in later geologic periods that too escaped from the earth's interior. Similarly other inert gases like xenon and krypton are virtually missing from the earth. Hydrogen and helium might have also escaped to space; only found in traces in the upper atmosphere. Through the escape of hydrogen from the earth there had been an oxidizing atmosphere. The hydrogen of methane (CH_4) and ammonia (NH_3) might have been lost slowly leaving nitrogen in the earth's atmosphere. On the other hand, giant planets like jupiter and saturn retained the gases, even most of their exceedingly volatile hydrogen and helium. Uranus and neptune lost much of their hydrogen, helium, methane and neon, but retained water and ammonia and less volatile materials.

Water, ammonia and hydrocarbons, such as methane might have condensed into solid and liquid forms in parts of these protoplanets. The dusts might have been coagulated by vast snow storms in the regions lying between the present planets. In course of long periods objects consisting of water, ammonia, hydrocarbons and iron or iron oxide were formed. It has been evidenced that the silicate is the most common compound forming the earth's crust today. High temperatures reduced iron oxides to iron in presence of hydrogen at that time. The molten iron being heavier sank through the silicates and accumulated in large pools. Today we find the core of the earth dominated by ferrugenous materials.

2.1.2.1. Origin of continents and ocean basins

The general morphology of earth's surface is distinctly divided into two parts — continents and ocean basins. Not simply the continents are located higher than the oceans, but these are formed of different materials. The continents are composed of granitic rocks, commonly known as *SiAl* (rich in silica and aluminium) crust, whereas the ocean floors are constituted of basalts mainly, called *SiMa* (rich in silica and magnesium) layer.

There are different opinions regarding the formation of the continents and ocean basins. Some considered that differential conditions of the continents and ocean basins were due to chemical evolution — the areas covered by water developed differently from those exposed to atmosphere. Another view suggests that the progressively cooling earth from molten mass was first crusted with thin layer of granites. This layer was parted later to expose the basalt layer. In many cases due to catastrophic volcanic eruption molten magma came out. It is suggested that the earth's crust was originally basaltic, later separation of ingredients occurred due to deformation in earth's crust to form distinctly the continents and ocean basins. Another dominant view is that the granitic rocks crystallized and floated on the top as the molten earth cooled down.

2.1.2.2. Origin of the atmosphere

Present atmosphere is constituted by nearly 4/5th of nitrogen and 1/5th of oxygen along with little amount of carbon dioxide, argon and many other gases in trace amounts. Since the inception of the earth the atmosphere had undergone many changes in different geological periods in the past. The atmosphere had been stabilized through various processes in the present form by the Cambrian Period, about 580 million years ago.

It is observed that the elements which constitute the earth's atmosphere seem to be scarce in other planets of the solar system. Plausible explantion for its origin might be sought by understanding the composition of the earth's atmosphere. Presently the dominant constituent gases are : nitrogen (78.08%), oxygen (20.95%), argon (0.93%) and carbon dioxide (0.035%).

All these form 99.99 percent of the total volume of the atmosphere. Two lightest elements, i.e. hydrogen and helium are found in the outer reaches of the earth's atmosphere, but rarely found close to the earth's surface. This condition developed through eons of geologic time along with slow changes that shaped the present lithosphere and hydrosphere. At the initial stages of inception of the earth from cosmic gases a weak gravitational field persisted and might have allowed the lightest gases like hydrogen and helium to wander close to the space. Moreover the present gases that prevail in the atmosphere are not direct residues of the earliest form of the planet. These gases probably have been transformed, constituted the second atmosphere, which evolved from volcanic eruptions, hot springs, chemical breakdown of solid matter, and later moderated by the plant life. At the beginning there might have been an excess of water vapour (60-70%), carbon dioxide (10-15%) and nitrogen (8-10%), but no oxygen in the earth's atmosphere. The condition of the earth's surface was very hot and with cooling the resultant condensation yielded incessant rainfall continuing for long geological periods. The water from the rainfall filled in the cavities of the earth's surface to form the oceans, seas and lakes. Thereafter there was evolution of plant life. The emergence of plant life on earth had tremendous effect upon the atmosphere. Slowly but steadily there was transformation of the atmosphere, plant life assimilating carbon dioxide from the atmosphere for photosynthesis and releasing oxygen to the atmosphere. Even today the interaction of land, water, air and plant and animal life constantly uses and renews the atmosphere and a delicate balance is maintained for the principal constituent gases of the atmosphere. The decay of plants, weathering of rocks, burning of fuel and breathing of animals — all use oxygen and release carbon dioxide. On the other hand, the balance is maintained by the utilization of carbon dioxide and release of oxygen by the plant life and also partly by the oceans. Even there has been exchange of carbon dioxide between the oceans and the atmosphere — an estimated 200 billion tonnes of carbon dioxide is exchanged per year. Nitrogen undergoes a complex cycle of transformation through bacterial activity in the soil, animal tissue, organic processes in decay, and released again to the atmosphere.

Such transformation of the status of the atmosphere is very important in understanding the environment of the past and also of the present. We will also examine the changing pattern of climate in the past and present decades with particular reference to global warming later.

2.2. Components of the earth

Environment means the surroundings. The air we breath, the land surface where we live, the water bodies that supply water, and all living organisms around us constitute our environment. Environment basically consists of all living and non-living things which surround us. In that sense environment has both biotic and abiotic constituents or components.

The abiotic components are : i) Atmosphere, ii) Lithosphere, and iii) Hydrosphere. Biosphere holds the biotic components.

2.2.1. Atmosphere

The atmosphere is one of the principal components of environment. The atmosphere means the gaseous envelope of air which clings to the earth's surface. It is as much a part of the earth as the land and the oceans but differs from them in many respects. The nature, characteristics and different processes in the atmosphere determine the status of environment. It is worthwhile to understand the nature, characteristics and dominating processes in the atmosphere.

The atmosphere in other word is called ***air***. Air is the mixture of a number of gases, water vapour and a variety of fine particulate and suspended materials. The gaseous mantle, called air has some unique characteristics.

2.2.1.1. Nature of air

Pure air appears to be colourless, odourless, and tasteless. The existence of air cannot be felt unless it is in motion. The other characteristics of air is its mobility, compressibility and expansionability. All such characteristics are important, as we find density of the air varying with altitude. The density of the air decreases with increasing altitude, so the air close to the earth's surface exerts more pressure. It can also transmit compression waves such as sound waves. Air is transparent to many forms of radiation, whereas some ***Green House Gases*** (GHGs) are not, otherwise the earth would have been turned into a frozen land surface. Air also forms a canopy in offering resistance to the objects like meteors which invade the atmosphere from the outer space. The meteors are destroyed through friction before they can reach the earth's surface. Without the air there would have been no clouds, winds, storms, and better to say no generation of weather systems. As a result there could not be any life-form on earth's surface. The envelope of air protects the life-forms as a shield from the ultraviolet radiation of the sun. It is the unique feature of our living planet.

The total mass of the atmosphere is approximately 5.2 $\times10^{15}$ tonnes(a) and nearly 50 percent of the total mass of the atmosphere (air) lie within 5500 metres (5.5 km) and about 99 percent lie within 30 kilometres from the surface of the earth.

2.2.1.2. Composition of air

We have broadly accounted for the composition of the atmosphere in our discussion on the origin of the atmosphere. The air in the atmosphere is mixture of different constituent gases, but not a compound as all the constituent gases in the atmosphere maintain their unique individual properties. Moreover it has been found that the composition of different gases in the lower reach of the atmosphere is nearly constant. Hence the zone (upto 100 km) of this constant composition of constituent gases is termed ***homosphere***. Beyond this limit the composition of gases differs, and is called the ***heterosphere***.

The composition of different gases in the homosphere is considered very important, as this is the most effective zone of weather-making, which exerts tremendous control over the environment. In the following table the composition of different gases in the lower atmosphere (0-25 km) has been stated.

(a) calculated on the basis of air pressure (weight) per unit area and total area of the earth's surface as 1.026 kg per sq cm and 5.1×10^{18} sq cm respectively. — Editor.

Table 2.1. Composition of different gases in the lower atmosphere (0—25 km)

Element	*Symbol*	*Percent by volume (dry air)*
Nitrogen	N_2	78.08
Oxygen	O_2	20.98
Argon	Ar	0.93
Carbon dioxide	CO_2	0.035
Neon	Ne	0.0018
Helium	He	0.0005
Ozone	O_3	0.00006
Hydrogen	H	0.00005
Krypton	Kr	Trace
Xenon	Xe	Trace
Methane	CH_4	Trace
Water vapour	H_2O	Small but variable (0-4%) in local air

From the table it appears that nitrogen, oxygen, argon and carbon dioxide constitute nearly 99.99 percent of the total volume of air in the lower atmosphere. Other constituent gases are neon, helium, ozone, hydrogen, krypton, xenon and methane. Of these ozone is very important, though it occupies only 0.00006 percent volume of air and when compressed its thickness would be only 3 mm in hundreds of kilometres of the atmosphere.

2.2.1.3. Properties of principal gases in the atmosphere

Nitrogen : Nitrogen is an inert gas. Nitrogen cannot combine directly with other gases. Nitrogen is present in different organic compounds particularly in proteins. Amino acids essential for the creation of life, are derived from nitrogen. The atmosphere is the storehouse of free gaseous nitrogen, whereas nitrogenous compounds are found in the bodies of the organisms and soils. The living organisms, except some nitrogen-fixing bacteria like ***Azotobacter, Clostridium, Derxia, Rhizobium*** etc., cannot utilize nitrogen directly from the air. It is to be converted into nitrate to be utilized by the plants. The plants use them in the synthesis of amino acids and proteins, and convert them into their tissues. Herbivores consume the plant proteins and convert them into their tissues. Carnivores get proteins from the herbivores and convert them into their body tissues. The dead plants and animal bodies and their excreta are decomposed by various decomposers and subsequently gaseous nitrogen is released to the atmosphere. The nitrogen cycle in the biosphere is very important for the sustenance of life.

layer and is formed of granitic rocks. Below the Sial lies the zone rich in silica (Si) and magnesium (Ma, so written in place of Mg the actual chemical symbol of the element for phonetic reasons) and is called the *SiMa* layer. The Sima layer is basically formed of basalt rocks and constitutes the ocean floors. The rocks constituting the ocean floors appear to be heavier than the rocks forming the continents. The basalt has specific gravity of 3.2 compared to 2.9 of the granitic rocks. Below the Sima layer density increases with the depth. Such difference in density causes the constituting layers floating over the other. The floating of the continents of large segments of the earth's crust appear, as plates, which move and carry the continents along. The tectonic processes (earth movements such as earthquakes) on earth's surface are the results of such movements. The Sial layer is relatively thin over the lowlands than it is over the areas covered by mountains. The continents intrude downward below the mountains in proportion to the heights of the mountains. Moreover when there is wearing away of the mountains the depressed material rises.

The mantle : Below the lithosphere lies the mantle. The mantle constitutes the bulk of the earth. It has the average thickness estimated at about 2800 km. The mantle is divided into two parts — upper mantle and lower mantle. The upper mantle is known as ***Asthenosphere*** and the lower mantle as ***Mesosphere***. The specific gravity of the outer mantle rock ranges between 3 to 3.5, but the specific gravity increases to 4.5 and more with increasing depth. The upper part of the asthenosphere displays the characteristics of plasticity and may be deformed and molten subject to the release of external pressure.

The Core : The most interior of the earth is known as the core. The core is formed by metallic minerals, mostly by iron, nickel and cobalt mixed with sulphur and silica. This is so called the *NiFe* layer rich in nickel and iron. The core extends for about 3500 km out of which 1250 km is included in the inner core and 2250 km in the outer core. The inner core appears to be solid and the outer core as molten metallic core. The specific gravity in the core may be as high as 13 compared to 2.8 for the rocks of earth's crust. The temperature at the core is also extremely high ranging between 5000 to 5500°C.

2.2.2.1. Composition of the earth's crust

Rocks and minerals

The earth's crust is covered by a hard veneer and may be considered as a mineral skin. This hard cover is composed of rocks and covers more than 70 percent of the earth's crust. The rocks are aggregate of minerals. The grains of two or more minerals are held in combination by any cementing material that particularly fills the spaces between adjacent mineral particles. The minerals in turn are constituted of varying chemical elements. Generally eight chemical elements are abundant in earth's crust.

Table 2.2. Elemental composition of the earth crust (percent by weight)

Element	*Symbol*	*Percent by weight*
Oxygen	**O**	**46.6**
Silicon	**Si**	**27.7**
Aluminium	**Al**	**8.1**
Iron	**Fe**	**5.0**
Calcium	**Ca**	**3.6**
Sodium	**Na**	**2.8**
Potassium	**K**	**2.6**
Magnesium	**Mg**	**2.1**

Oxygen is the most abundant element found on earth's curst constituting nearly half of the total weight. Silicon is found next to oxygen constituting more than 1/4th of the total weight. Aluminium and iron come next, followed by calcium, sodium, potassium and magnesium. Outside the list are titanium, hydrogen, phosphorous, barium and strontium. It is interestingly observed that many important metallic elements, namely copper, lead, zinc, nickel and tin are scarce on the earth's surface.

Classification of rocks

Rocks are classified according to their mode of origin and chemical composition. Accordingly rocks are broadly classified into three types namely : i) Igneous or Primary rocks, ii) Sedimentary or Stratified rocks and iii) Metamorphic rocks. These rocks are divided into many other types based on their chemical composition.

Igneous rocks : When the magma from the interior of the earth pours out, it flows as lava on earth's surface or may solidify within the earth's crust. These are molten materials and also rich in gases. As these molten materials are solidified due to cooling the igneous rocks are formed. The nature of cooling and the site of formation decide the type of igneous rocks. These rocks are also classified according to their chemical composition.

Sedimentary rocks : The primary or igneous rocks had been subject to weathering and erosion since their formation. The landforms formed by these rocks had been denuded and detritus materials carried over by different agents of erosion like river, glacier and wind to seas and lakes, where these sediments were deposited. Over long period of time these sediments had undergone physical or chemical changes or had become compacted and hardened to form rocks, called sedimentary rocks. These are defined as sedimentary rocks, because they are formed of sediments. The sediments are also deposited in different layers in different periods. Hence these rocks are stratified and have bedding planes. Bedding planes are the planes of separation between the layers. As such, the sedimentary rocks are sometimes referred to as the stratified rocks. Important sedimentary rocks include sandstone, limestone, mudstone, shale etc.

Metamorphic rocks : Metamorphism means changed nature of any material. The igneous and sedimentary rocks undergo transformation by tremendous pressure and high temperatures subject to tectonic movements of earth's surface. As a result a new variety of rock emerges out of parent rock, commonly being more compact, crystalline and harder than the original rock. This type of rock is called metamorphic rock and the process is known as metamorphism. The most common metamorphic rocks are gniess (metamorphosed from granite), quartzite (metamorphosed from sandstone), slate (metamorphosed from shale), marble (metamorphosed from limestone) etc.

2.2.3. Hydrosphere

Hydrosphere is the other important part of the earth's surface. Hydrosphere broadly means the waterbodies on earth's surface. The extensive and vast waterbodies are defined as oceans and seas and are distinctly different in their characteristics from the land surface. The waterbodies on land surface are also found, but these have less significance than oceans and seas. The oceans and seas cover nearly 71 percent of the total area of earth's surface. The lands occupy the rests nearly 29 percent of the earth's surface. The distribution of land and water surface in the two hemispheres appears to be juxta-opposite or antipodal — northern hemisphere dominated by the land surface and southern hemisphere almost occupied by ocean bodies.

2.2.3.1. Oceans and seas

The term world-ocean refers to combined ocean bodies and seas of the globe. Hydrosphere on the globe covers nearly 361,059,200 sq km. Of these the Pacific ocean, the Atlantic ocean and the Indian ocean are the principal water bodies. These oceans in total include nearly 89 percent of the total area of the hydrosphere. The area and volume of different oceans and seas are presented in the following table.

Table 2.3. Oceans and Seas — Mean areas and volumes

Name	*Area in sqkm*	*Volume in cukm*
Atlantic Ocean	82,441,500	323,613,000
Indian Ocean	73,442,700	291,030,000
Pacific Ocean	165,246,200	707,555,000
Oceans Total	321,130,400 (88.94%)	1322,198,000 (96.5%)
Arctic Sea	14,090,100	16.980,000
Malay Sea	8,143,100	9,873,000

Name	*Area in sqkm*	*Volume in cukm*
Central American Sea	4,319,500	9,573,000
Mediterranean Sea	2,965,900	4,238,000
Inter-continental Seas Total	29,518,600 (8.2%)	40,664,000 (2.96%)
Baltic Sea	422,300	23,000
Hudson Bay	1,232,300	158,000
Red Sea	437,900	215,000
Persian Gulf	238,800	6,000
Smaller Enclosed Seas Total	2,331,300 (0.64%)	402,000 (0.03%)
Bering Sea	2,268,200	3,259,000
Okhotsk Sea	1,527,600	1,279,000
Japan Sea	1,007,700	1,361,000
East China Sea	1,249,200	235,000
Andaman Sea	797,600	694,000
Californea Sea	162,200	132,000
North Sea	575,300	54,000
English Channel & Irish Seas	178,500	16,000
Laurentian Sea	237,800	30,000
Bass Sea	74,800	5,000
Fringing Seas Total	8,078,900 (2.22%)	7,059,000 (0.51%)
Hydrosphere	361,059,200	137,032,500

It appears from the table of all the oceans, the Pacific Ocean is largest in area and has largest volume of water, followed by the Atlantic Ocean and the Indian Ocean. The Inter-Continental Seas cover nearly 8 percent area and 3 percent volume of water in the hydrosphere. Next to it comes the Fringing seas, which occupy nearly 2 percent area and 0.5 percent volume of water in the hydrosphere. The Smaller Enclosed Seas occupy the least area (0.64%) and least volume of water (0.03%) in the hydrosphere, but these enclosed seas are of great significance.

General characteristics of the oceans : The depth of the oceans and seas vary considerably. The marginal seas along the land-front are less deeper, where the continental shelf is extensive. The continental shelf is the extended part of the continents into the oceans. The depth of the continental shelf lies within 200m. From the table, it can be seen that the Atlantic Ocean has the largest extension of the continental shelf (13.3%), compared to the Pacific Ocean (5.7%) and the Indian Ocean (4.2%). Next to continental shelf the relief of the ocean floor changes to a comparatively sloping gradient known as continental slope, which ultimately meets the nearly flat bottom surface of the oceans. This flat bottom areas of the oceans are called deep sea plains, which account for the maximum area (nearly 83%) of the oceans (excluding the adjacent seas). The deep sea plains have depths in different oceans ranging between 2000m to 6000m. The Pacific Ocean, the Indian Ocean and the Atlantic Ocean occupy deep sea plain covering respectively 90.6 percent, 90.6 percent and 85.8 percent of the total area. Many parts of the oceans record depths more than 6000 m, but occupy not more than 1.2 percent of the total area of the oceans. These are called ocean deeps. Most of the ocean deeps are found in the Pacific Ocean and a fewer in the Atlantic and the Indian Ocean. Of different occean deeps the Mariana or the Challenger in the North Pacific Ocean has the maximum depth (5269m) in the world. Next to it comes the Tonga Deep, located in the Central South Pacific Ocean having a depth of 5022m. Other important ocean deeps are the Philippine Deep (4767m), the Japan Deep (4655m), the Murray Deep (3540m) in the Pacific Ocean, the Puertorico Deep (4662m), the Romanche Deep (4030m) in the Atlantic Ocean and the Sunda Deep (3828m) in the Indian Ocean.

Distribution of temperature and extent of salinity in the oceans vary latitudinally. Relatively high temperature condition prevails over the tropical oceans. The warm equatorial currents originate close to the equator and flow towards the pole as surface current. On the other hand, cold conditions dominate uniformly over the polar regions, which become the source of cold currents that move towards the lower latitudes. Temperature in the oceans also varies according to the depth. Usually three structured layers of temperatures are observed — near the surface upto a depth of 500m warm surface temperature, sharp decline of temperature in the zone of 500m to 1000m known as thermocline and uniform cold temperature below the depth of 1000 m. The vertical temperature distribution in the ocean is very important to study the environment for life. The upper layers where the sunlight can penetrate is known as ***limnetic zone***. In this zone active photosynthesis and growth occur resulting in abundance of oxygen and rapid consumption of nutrients. So the limnetic zone is usually rich in aquatic species. Next to limnetic zone are the ***profundal zone*** and ***benthic zone***. These zones are dark, but decomposition, mineralization and nutrient accumulation occur. In these dark zones dissolved oxygen is deficient and anaerobic microbial activity predominates. Salinity of sea-water appears to be high in the tropical seas under arid condition. The salinity increases sharply in the enclosed seas where the mixing of water is nearly absent. The Red Sea and the Mediterranean Sea record very high salinity. The salinity in the low latitudes also varies with depth, increasing steadily to a certain depth (-100 to -200m) and then decreasing sharply to a minimum at a depth of 800 m.

2.2.3.2. Significance of hydrosphere

The hydrosphere is of immense importance to mankind. Through the process of evaporation the oceans supply water vapour to the atmosphere. The water vapour being condensed in the atmosphere causes precipitation on the earth's surface. The running water flows as river and finally meets the sea. A part of the precipitation is collected through seepage as underground water and forms the water table. The plants absorb water from the underground sources and the water is again released to the atmosphere through the process of evapotranspiration. The process continues and the oceans and the atmosphere actually determine the status of water and moisture on our living earth. The process is called the hydrologic cycle. One estimate shows that the oceans contribute annually $4.49\text{x}10^{17}$ kg of water to the atmosphere through evaporation, but get back only $4.12\text{x}10^{17}$ kg as precipitation. Evaporation from the waterbodies of land surface and evapotranspiration from plants add annually $0.71\text{x}10^{17}$kg of water to the atmosphere, but get about $1.05\text{x}10^{17}$ kg of water as precipitation, i.e. in excess of evaporation. Of these nearly $0.37\text{x}10^{17}$ kg flow back to the oceans as runoff by different rivers and streams. The rest of the water is retained by the land surface, which is essential for the sustenance of life on the earth's surface. The operation of the hydrological cycle is crucial to the Hydrologic cycle availability of fresh water to the biosphere especially to the land-based ecosystems.

The oceans are a great reservoir of carbon dioxide. They can absorb more carbon dioxide than the atmosphere. The stored carbon dioxide amounts to about 130,000 billion tons, nearly 50 folds more capacity than the atmosphere. Moreover the oceans exchange 200 billion tons of carbon dioxide with the atmosphere each year. The reserve of carbon dioxide in the oceans acts, within certain limits, as a regulator. When there is excess carbon dioxide in the atmosphere the oceans absorb, but where there is deficit the oceans replenish the atmosphere.

The oceans are the storehouse of yast resources — supplying water, salts, minerals and food. The resources of the oceans have not yet been wholly tapped and will survive many millennium, if there be judicious utilization. The oceans also play important role as receptacle of pollutants and waste materials from the land surface. But this role of the oceans must be controlled and kept within limits through less generation of hazardous wastes and pollutants on land surface. The oceans since the dawn of civilization play the significant role in transportation.

The role of the hydrosphere, appears to be critical when we consider the sustenance of life on earth's surface. It is known that the first emergence of life occurred under marine conditions. The hydrologic cycle illustrates the importance of the oceans supplying freshwater to the land surface otherwise the existence of life on land surface would not have been possible. We must realize that this water resource on land surface is very limited and scarce.

2.2.4. Biosphere

The biotic component of the earth is present in the biosphere. The biosphere encompasses all the three spheres of the earth's surface. So it is a rather thin layer of living system within the atmosphere, the lithosphere and the hydrosphere. Sometimes it is referred as the ecosphere that may be actually conceived as a gigantic network of ecosystems; each ecosystem is, however, an open one.

The ecosystem is a complex system in which interactions between various components of environment take place. Here all the living and non-living constituents, as spatial and organizational units, interact with each other and result in the exchange of materials between them. The ecosystem may be real-type like pond, field, forest, marine etc. or may be hypothetical. So different types of ecosystems can be identified. These include say, terrestrial ecosystem, wetland ecosystem, marine ecosystem or more specifically these can be divided into mountain ecosystem, desert ecosystem, pond ecosystem, grassland ecosystem, forest ecosystem, littoral ecosystem etc. All life-forms on the earth's surface depends on the transfer of energy from one community of species to the other. Sun is the basic source of energy and biological activity utilizes the energy that comes from the sun. This radiant energy is converted to chemical form (carbohydrates) by the plants through the process of ***photosynthesis***. Afterwards the energy transfer takes place from the chemical to mechanical and heat forms in cellular metabolism. This energy flow in the ecosystem is unidirectional and non-cyclic, whereas the nutrient movement is cyclic.

There are three principal communities in the biosphere, namely **i)** producers, **ii)** consumers, and **iii)** decomposers. The term 'Producers' is misleading, the better term may be the converters. These are the plants which convert radiant energy into chemical energy. The consumers include both the ***herbivores*** and the ***carnivores***. In the food chain system the carnivores depend on the herbivores and the herbivores on the plants or autotrophs for energy and nutrient flow. The exudates and excreta of plants and animals and also their dead bodies are decomposed by the activity of decomposers that include different bacteria, fungi and other micro-organisms. In the ecosystem both energy and nutrient flow to the decomposers from the preceding levels. In the transfer of energy from one trophic level to the other there is a steady diminution of energy. The nutrients are ultimately released by the decomposers into the environment, which are then available for reuse and recycling.

2.2.4.1. Biodiversity

When man's immediate ancestor first appeared on the surface of earth about 2 million years ago, the world was biologically rich in millions of other species including plants, animals, fungi, and microorganisms. The biological richness of the earth remained part of the habitat and shaped the destiny of man. Even today our existence is closely related to it, as the biosphere constitutes an essential life-support system to us.

Diversity of life is expressed in terms of biological diversity, which is the total variety of life-forms on the earth's surface. It refers to the sum total of varieties of species — microbes, plants, insects, amphibians, reptiles, birds and mammals found in the biosphere and associated with the ecosystem. Biological diversity is studied at three different levels : (i) Diversity of biotic communities within an ecosystem, (ii) Diversity of species within a community, and (iii) Diversity of genetic organization within a species.

2.2.4.2. Importance of biodiversity

Biodiversity is essential in supporting human life and society and we depend, to a great extent, on other organisms. Our food, medicines, many vital chemicals, materials for our shelter and clothings come from the living things surrounding us. If there be dearth of these things it would seriously affect our life. We must understand the importance of richness of biological species in our own interest and we must know that :

i) All food ultimately come from plants — the energy that sustains human life and all other life forms on earth's surface is produced entirely by the plants through the process of photosynthesis. Energy is transferred from one trophic level to other trophic level, but at a diminishing rate.

ii) All medicines for human ailments are derived from living organisms — many of the medicines come directly from different plants, fungi and bacteria. Even the medicines that are at present synthetically prepared were originally discovered in nature. The importance of biotic medicines are increasingly felt in the modern world.

iii) Biological diversity is a pool of valuable genetic resource — the genetic organization of traditional and wild varieties of plants and animals are time tested evolution of species for millions of years. This will remain the collection of traits and gene-pool for future. Hence reduction in biological diversity results in adverse effect upon future breeding and improvement of species.

iv) Biological diversity appears to be an instrument for the preservation of ecosystem — all species in a particular ecosystem live interdependently. Any loss of a particular species will break the food chain or food-web in the ecosystem and the life supporting system of other dependent species will be jeopardized.

Due to such importance of biological richness for our life supporting system, the historic UNCED (United Nations Conference on Environment and Development) Earth Summit held at Rio de Janeiro in Brazil in June, 1992, discussed and recognized the value of biodiversity. The Convention reaffirmed :

i) the intrinsic value of biological diversity;

ii) the soverign rights of states over their biological resources;

iii) the fundamental requirement of *in situ* conservation of ecosystems and natural habitats;

iv) the supporting role of *ex situ* measures;

v) the vital role of local communities and women in the conservation and sustainable use of biological diversity;

vi) the desirability of sharing equitably the benefits arising from the use of traditional knowledge, skills, innovations and practices;

vii) the importance and the need to promote regional and global cooperation for conservation; and

viii) the requirement of substantial investments to conserve biological diversity.

2.2.4.3. Biodiversity in India

India is immensely rich in biological diversity. Such richness is attributed to the vast variation in physiographic and climatic conditions in India. Here we find different ecological habitats ranging from tropical rainforest, sub-tropical savanna or shrublands, temperate forest, alpine mosses to xerophytic vegetation of the desert. Biogeographically India represents two of the major realms (Palaearctic and Indo-Malayan) and three biomes (Tropical Humid Forests, Tropical Dry/Deciduous Forests, and Hot Deserts and Semi-Deserts). India can be basically divided into 10 bio-geographic regions : (i) Trans-Himalayan, (ii) Himalayan, (iii) Indian Desert, (iv) Semi-Arid, (v) Western Ghats, (vi) Deccan Peninsula, (vii) Gangetic Plain, (viii) North-east India, (ix) Coastal, and (x) Islands.

More than 45,000 plant species have been estimated to be present in India, accounting for nearly 7 percent of the flora in the world. Of these 15,000 are estimated to be the flowering plants. The other important plant groups we find are 64 gymnosperms, 2843 bryophytes, 1012 pteridophytes, 1940 lichens, 12480 algae and 23000 fungi. The faunal wealth is no less diverse. The animal species are estimated to be around 81000. This accounts for 6.4 percent of the world's fauna. Of the invertebrates more than 5000 are molluscs and 57000 insects. The vertebrates include 2546 fish, 204 amphibians, 428 reptiles, 1228 birds and 372 mammals. However, we have only a limited knowledge on the diversity of microorganisms in India.

2.2.4.4. Global biodiversity

It has always been very difficult to estimate the total number of species on the earth's surface. Until 1980 it was estimated to be ranging between 10 to 30 million, which later rose to 30 million species after taking account of the insects living in the high foliage of trees in tropical forests. The optimistic estimate for the total population of species even has been set at 100 million. However, from different taxonomic studies we can so far show only about 16 million species.

Table 2.4. Number of species in major taxonomic groups

Taxonomic Groups	*Species*	*Numbers*
Invertebrates	**Protozoa**	**502,000**
	Porifera	**10,000**
	Coelanterata	**9,000**
	Platyhelmenthes	**12,000**
	Nematoda	**10,000**
	Mollusca	**100,000**
	Annelida	**8,200**
	Arthropoda	**920,000**
	Echinodermata	**6,000**

Taxonomic Groups	*Species*	*Numbers*
Vertebrates	**Pisces**	**23,000**
	Amphibia	**2,400**
	Reptilia	**5,200**
	Aves	**8,300**
	Mammalia	**4,200**
	Total number of animal species	**1,168,500**
Lower green plants	**Algae**	**20,175**
	Fungi	**80,000**
	Bryophytes	**14,900**
	Pteridophytes	**11,000**
	Conifers	**650**
Flowering plants		**300,000**
Total number of species of plants and animals	**1,595,225**	

We can compare the biological diversity in India with the above table. It is glaringly exhibited that India stands as one of the richest country in biodiversity.

2.2.4.5. Threat of extinction

The biodiversity of earth's surface has now been faced with mass extinction of many species on a global scale. Every type of organism — microorganisms, fungi, plants, and animals all are threatened with dire consequences. Many of the animals species have already been lost, out of which mammals include 60, reptiles 30 and birds 75. Moreover nearly 650 mammals, 210 reptiles and 1100 birds are threatened with extinction. The loss of biodiversity is mostly pronounced in the tropical rainforests. The rainforests in the tropics have been alarmingly disturbed and cleared for expansion of agriculture, logging, mining and many other activities by man. Destruction of these forests has resulted in the degradation of environment and habitat of the species. In many cases the production (usually industrial) and release of wastes acting as pollutants have completely destroyed the habitat of many species. Moreover the habitat areas in most cases have got shrunk due to many reasons and stand as isolated patches or islands. Charles Darwin observed that smaller the area of the habitat, the lower would be the number of species. It has become imperative to take an all out coordinated effort to protect the habitat, particularly in the tropical forest.

Threatened plant and animal specie in India :

2.3. Climate of the earth

The term climate comes from the Greek word ***klima*** meaning the slope of the earth. The Greek philosophers identified different thermal belts on earth's surface, which indicated typical climatic conditions, based on distribution of insolation or radiant energy from the sun on earth's surface. There has been latitudinal variation of insolation, which results in varying temperature conditions in different parts of the earth's surface. The variation of temperature conditions is also affected by various other factors of which the positions of continents and oceans are of great significance in moderating the climate of any place. In general we find that the littoral area enjoys mild climate, whereas the interior of continents experiences harsh climate.

2.3.1. Oceanic and continental effect of climate

The oceanic and continental characteristics of climate are manifested due to contrasting nature of land and water. Differential heating of land and water causes varying types of climate in the lands close to the sea and the interior of the continents. This contrast in climate has been contributed by some other factors like orographic barriers, ocean currents, movement of airmass and relative positions of high and low pressure belts. In general the following climatic conditions prevail in the coastal lands and interior of the continents.

Latitudes	*Location*	*Climatic conditions*
Lower (Tropics and sub-tropics)	**Coastal**	**Moderate temperature (annual range low), moderate to high rainfall, dominance of land and sea breeze**
	Inland	**Extreme temperature conditions (annual range high), low rainfall, harsh arid or semi-arid climate**
Middle (Temperate)	**Coastal**	**Moderately warm in summer, no freezing in winter, moderate rainfall due to mid-latitude cyclone**
	Inland	**Extreme cold in winter, low rainfall, dominated by continental polar air mass**

Such variation of climates in the coastal and inland areas are caused due to many factors. We can enumerate a few of these factors.

i) It has been found that the albedo of the land surface exceeds albedo of the water surface. The average albedo of the land surface is estimated at 35 percent, whereas the albedo of the oceanic surface ranges between 7 to 23 percent only. The ratio of the amount of insolation (solar radiation) reflected to the amount received on the earth's surface is defined as the albedo. The following table shows the estimated mean albedos of various surfaces.

Table 2.5. : Estimated mean albedos of various surfaces

Surface	*Albedo in percent*
Tropical forest	21
Deciduous forest	18
Coniferous forest	13
Savanna	15
Desert	28
Oceans (60-70 degree latitude)	7-23
Inland waters	2-78
Snow	70-90

As a result of difference in albedo between land and water, the water surface gets more radiant energy for heating. Moreover, as the specific heat of the land surface is higher, the land surface becomes heated sharply during day and cools rapidly during night. On the other hand the large bodies of water heat and cool slowly compared to the land surface. In addition the heat in the water bodies is redistributed through turbulence. Heated water on the surface layer goes to the bottom layer and cooler water from the bottom replaces it. So heat is distributed and temperature remains moderate.

ii) Land and sea breeze develop in the coastal areas due to diurnal change in temperature conditions, particularly over the lands. In day time the land becomes heated and a low pressure develops. On the contrary the sea remains cooler having the high pressure. So maritime winds blow towards the land, known as ***sea breeze***. During night the condition is reversed — the land becomes rapidly cooler, but the sea retains the temperature and remains warm. So during night the winds blow from the land towards the sea. This breeze is called the ***land breeze***. The land and sea breeze is most common over the tropical and sub-tropical coast lands. These are even experienced in high latitude coastal areas.

iii) The monsoon circulation over the tropics is also primarily caused due seasonal change of temperature and pressure conditions over lands and seas. In summer when the land becomes extremely heated low pressure belt emerges in northwestern India and Pakistan and also over the central Asian landmass inviting the moisture bearing winds from the oceans (in south Asia from the Indian Ocean and in southeast and east Asia from the Pacific Ocean). Many of these monsoon circulations travel as depressions and cyclones, which cause heavy rainfall. The amount of rainfall decreases steadily away from the coast.

iv) The ocean currents also play significant role in moderating the climate of the coastal areas. The Gulf Stream or the North Atlantic drift, as warm ocean current, keeps warm the adjoining coastal lands. The northwestern Europe remains warmer than the central Europe lying in the same latitude due to its influence. Similarly Japan remains warmer than the central Asian land mass due to warm Kuroshio Current.

v) The interior lands of Asia are girdled by, mountain chains which act as barrier to the movement of air mass. So the monsoon current from south and southeast Asia cannot penetrate inland due to such topographical barriers. As a result arid to semi-arid conditions prevail over central Asia. On the other hand central Asia stands open to the cold airmass from the polar areas, where the temperature drops below the freezing point. But this cold airmass fails to penetrate south and southeast Asian coastal lands, which remain warm even in winter.

2.3.2. Wind systems

The air has the property of compressibility and expansionability. Due to its property of compressionability the air can exert pressure. The maximum pressure is found at the sea level surface of the earth. The air pressure decreases with increasing height. At sea level the weight of air is equivalent to 14.7lb/sq inch (1.026 kg/sq cm) and the air pressure is 1013.2 mb. The density of the air also decreases with increasing height. At sea level the density of air is 1.2 kg per cubic meter, but decreases to 0.7 kg per cubic meter at an altitude of 5000m.

2.3.3. Air pressure

The air pressure is measured on the earth's surface by the height of the mercury column in the barometer. Normal air pressure is expressed by a height of 76 cm of mercury column. So the air pressure will be computed as $P = hpg = 76x13.6x980$ dyne or 1013000 dyne (or 1013 millibar). The air pressure varies on the earth's surface for many reasons. Normal air pressure at sea level at 45 degree latitude is taken as 1013 mb. The air pressure is controlled by both temperature and water vapour present in the air. With increasing temperature and humidity the air pressure decreases. So in summer over the land surface the air pressure is generally low compared to relatively high pressure in winter. The air pressure may be as high as 1025 mb and in case of severe tropical cyclone the barometric pressure may even decrease to 950 mb. On global scale there are marked variations of air pressure in different seasons and different latitudes. We can distinguish different pressure belts over the globe. These are called permanent or semipermanent pressure belts.

2.3.4. Pressure belts on the globe

The equatorial region on the earth's surface receives insolation throughout the year. So a permanent low pressure belt is observed over the equatorial region and called Equatorial Low. Similarly the polar regions receive lowest insolation on the earth's surface and the temperature remains below freezing point in most parts of the year. Over the poles high pressure belts are observed, both at 90° N and 90° S. These are known as polar high. Both equatorial low and polar high are the consequences of thermal conditions. These are sometimes called thermal low and thermal high. Apart from these pressure belts high pressure belt is observed over the subtropical region at latitudes 30° N and 30° S and low pressure belt is found at subpolar region at latitude 60° N and 60° S. These are known as ***subtropical high*** and ***subpolar low*** respectively. These pressure belts are not caused by thermal conditions. These are called ***dynamic high*** and ***dynamic low***. It is observed that there are subsidence of upper air mass resulting in accumulation and thus causing high pressure over the subtropical region. On the other hand convergence of surface air (i.e. westerlies and easterlies) might have caused low pressure over the subpolar region.

2.3.5. Movements of air or generation of wind

Air moves from high pressure cell or belt to low pressure cell or belt. The air in motion is called wind. The horizontal motion of air is controlled by four important factors, which are referred as the laws of horizontal motion. These are namely : i) Pressure Gradient Force, ii) Coriolis Force, iii) Centripetal Acceleration, and iv) Frictional Force.

The horizontal motion of air is controlled primarily by the ***pressure gradient force***. The pressure gradient force is measured in terms of decrement of pressure per unit distance and is inversely proportional to density of air.

The other important control of the horizontal motion of air is the ***Coriolis force***. The Coriolis force results from the rotation of the earth, and the moving wind appears to be deflected to the right in the northern hemisphere, but to the left in the southern hemisphere.

The ***centripetal acceleration*** is also an imaginary force resulting due to conservation of angular momentum of a moving body around a circular path. According to Newton's First Law of Motion for a body to move in a curved path some force must be applied. The force containing the body to move in a curved path is called the ***centripetal force***.

The ***frictional force*** has important effect on air movement. The force results due to friction with the ground surface and therefore decreases with increasing altitudes.

2.3.6. General circulation of winds

We know that wind blows from high pressure belt to the low pressure belt. On a global surface the Subtropical High Pressure belts are the source regions of divergent winds, one moving towards the Equatorial Low Pressure belt and the others moving towards the Subpolar Low Pressure belts. The winds blowing from the subtropical Highs towards the Equatorial Low are known as Trades, North Eastern Trades in the northern hemisphere and South Eastern Trades in southern hemisphere. The Trades converge at the Equatorial Low and the point of their convergence is known as Inter Tropical Convergence Zone or I.T.C.Z. At the point of their convergence calm weather conditions prevail. This is referred as Equatorial Calm Belt or ***doldrums***. At the point of convergence, naturally, there will be rising air and transfer of heat and momentum from a heat source, i.e. the equator, towards the heat sinks, i.e., the poles. So the upper air in the tropics is expected to move just opposite to the surface winds, i.e. North Eastern Trades and South Eastern Trades.

The other divergent motion from the Subtropical High is directed towards the Subpolar Low. As a result surface wind blows over the mid-latitude region as Westerlies, as the deflection of winds is more with increasing Coriolis force. In the mid-latitude region the circulation, however, does not resemble the large convectional system. Here the surface flow is from a warm source to a cold source. The meridional temperature contrast is high over the mid-latitude region, particularly in winter months. This accounts for heat transfer by exchanges of air masses across the latitude belts. Rossby considered the role of the travelling polar and tropical airmasses towards the equator and the poles respectively most important for weather genesis in the mid-latitude region. The exchanges of air masses accompany the succession of cyclones and anticyclones in this latitudinal belt which move from west to east. These are also compounded with the upper tropospheric long waves which occur over the mid-latitudes. The Coriolis force is stronger in the mid-latitude region causing larger deflections than over the tropics. So the winds here are Westerlies.

The high latitudes or polar region experiences Easterlies. From the polar high the wind moves to the subpolar low as the Easterlies and converge with the Westerlies. At their point of convergence the air rises and blows towards the pole as upper air Westerlies. The air circulation over polar or high latitude cell resembles the circulation over the tropics.

2.3.7. Jet stream

A fast moving air stream at the top of the troposphere of the mid-latitude region, near the tropopause, blowing from a generally westerly direction and often exceeding 400 km per hour is known as the ***jet stream***. It is sometimes suggested that the jet is the creator of the cyclones, as maximum number of cyclones develop along the polar front. The jet, not only, steers the cyclone in mid-latitude region, but also greatly influences the pattern of precipitation and accounts for steepening surface temperature gradients. The role of the Jet Stream in the mid-latitude region attributes complex weather conditions at the surface.

2.3.8. Monsoon winds or circulations

The term monsoon has been derived from the Arabic word ***mausin*** (Urdu ***mausam***), which means season. Hence monsoon is a seasonal or periodic wind. Unlike the palnetary-winds the direction of monsoon circulations changes in alternating seasons. In summer in the northern hemisphere it blows from southwest to northeast, hence southwesterly. But in winter it moves from northeast to southwest, hence northeasterly. But it must be noted that the monsoon involves not only a seasonal wind but also one of thermal origin arising from the differential heating of extensive land and water. The monsoon winds are mostly confined in the tropics covering wide areas ranging from 25° S to 35° N latitude and from 45° W to 140° E. In that sense monsoon may be considered as a global circulation. The monsoon winds have been ideally developed over India. So India is sometimes referred as the ***land of monsoon.*** Southeast Asia also experiences monsoon climate. Tropical south west Africa from Nigeria to Sierra Leone and northern Australia also experience atlernating wind directions in summer and winter and enjoy monsoon-like climate.

2.3.9. Formation of clouds

We know that the cloud is the source of rainfall and snowfall on the earth's surface. The formation of clouds is related to the ascent of moisture bearing air parcel. As the air moves upward the pressure becomes lower with ascending heights. So there is loss of weight of the atmosphere upon it and the parcel of air expands in volume. The rising air is thus subject to expansion by which some energy is expended through work. Hence the temperature of the air parcel drops. Consequently, with the fall of temperature at dew point the process of condensation is initiated. As a result the latent heat of condensation is released in the atmosphere, which again acts as trigger in uplifting the air parcel to a higher level. This process of expansion is called the ***adiabatic expansion***, and the cooling as ***adiabatic cooling***. The adiabatic expansion and cooling in the atmosphere are considered important weather making processes. The instability or stability of the atmosphere is closely related with the adiabatic expansion and cooling. The rate of cooling in the atmosphere largely depends on the amount of water vapour present in air and the speed of ascent. The nearly saturated air with a steep ascent will be transformed into cumulonimbus cloud and result in the development of very unstable weather condition. All weather distrubances are usually related to developments of such atmospheric conditions.

The clouds in general indicate the physical processes prevailing in the atmosphere. As such the study of clouds have become relevant synoptic analysis of weather at any place. The understanding and recognition of cloud types help in the prediction of weather. From any cloud atlas different types of clouds can be identified. On the basis of their distinctive characteristics the clouds are grouped into 4 principal families and 10 classes.

Family A : High clouds (mean base level 6000 m)

1. Cirrus (Ci) — This type of clouds appears like feather and is formed of ice crystals. These are thin and of fibrous structure. When they are detached and arranged irregularly, they indicate fair weather. But when arranged in bands systematically and connected with cirrostratus or altostratus, they may foretell bad weather.

2. Cirrostratus (Cs) — This type of clouds look like a thin whitish sheet covering the whole sky. The sky thus assumes a milky appearance. The clouds produce a halo around the sun or moon, which is the harbinger of a storm.

3. Cirrocumulus (Cc) — These appear as white flakes or small globular masses and normally do not cast shadow. These are usually arranged in groups, lines or ripples characterzsing the sky as 'Mackarel' sky.

Family B : Middle clouds (mean upper level 6000 m and mean base level 2000 m)

4. Altostratus (As) — These clouds appear as a uniform sheet cloud of grey and bluish colour and normally have fibrous structure. They in many cases resemble the cirrostratus and

gradually merge with them. Widespread and continuous precipitation occur as a consequence of formation of these clouds.

5. Altocumulus (Ac) — These clouds have flattened globular form and arranged in lines or waves. Unlike the cirrocumulus they cast shadow and have larger globules.

Family C : Low clouds (mean upper level 2000 m and base level close to the ground)

6. Stratocumulus (Sc) — These are large globular masses or sprawls of soft grey clouds having brighter interstices. These are usually arranged in a regular pattern.

7. Stratus (St) — This type of clouds with uniform layers almost resembles the fog, but are detached from the ground.

8. Nimbostratus (Ns) — These low clouds are dense and shapeless. In most cases precipitation occurs from the ragged layers of low clouds.

Family D : Clouds with vertical development (no specific height, but may be as high as > 6000 m and as low as 480 m)

9. Cumulus (Cu) — These are the thick clouds with vertical development. These have dome structure with cauliflower appearance but the base is horizontal. Normally these clouds indicate fair weather.

10. Cumulonimbus (Cb) — These are sometimes referred as thunder clouds. They have large masses of vertical development, where the summits may look like mountains, towers or anvils. They characterize the atmospheric instability resulting in storm rainfall, squalls, thuderstorms and even hails.

2.3.10. Mechanism of precipitation (rainfall and snowfall)

It has been observed that simple condensation process and simple growth of cloud droplets are apparently inadequate mechanism to initiate precipitation. Precipitation means both rainfall and snowfall. Where the temperature drops below the freezing point in the atmosphere the snowfall occurs, otherwise the rainfall is the common phenomenon. The mechanism for the occurrences of both rainfall and snowfall is the same. A new concept of rain making has been proposed by Bergeron and Findeisen.

Bergeron-Findeisen theory : The role of ice crystals present in clouds along with water droplets has been highlighted in recent years to explain the mechanism of precipitation. Bergeron considered that the colloidal instability would result in a cloud consisting of a mixture of ice particles and super-cooled water droplets. The foundation of Bergeron-Findeisen theory of rain making lies in the following facts.

The relative humidity of air is greater with respect to an ice surface than with respect to water surface. As the temperature drops below 0°C the atmospheric vapour pressure falls very sharply than over the water surface. This induces saturation vapour pressure (SVP) over water becoming greater than that over ice, particularly between temperature -5 to -25°C. Where the difference of SVP exceeds 0.2 mb and ice crystals and supercooled water droplets exist together in a cloud, the latter (super cooled water droplets) tend to evaporate and deposit over the ice crystals (by the process of sublimation). Small water droplets can be supercooled in pure air to -40°C. However, spontaneous freezing takes place normally when temperature drops below -22°C. The role of the freezing nuclei is very important in the formation of ice crystals. The freezing nuclei are less numerous in a cloud than the condensation nuclei, only 10/litre at -30°C. Fine soil particles, aerosols, volcanic dust particles etc. may favour the formation of freezing nuclei. The freezing nuclei grow by deposition. Being detached from the parent one a new freezing nucleus may be formed separately, whereas the freezing of the super cooled water may lead to the formation of ice splinters. The ice crystals aggregate upon collision, particularly at temperature 0°C to -5°C.

As the ice crystals grow larger they cannot be suspended further in the free air and fall downwards. At the base of the cloud where the temperature exceeds 0°C the ice crystals form large water droplets and ultimately drop as rain on earth's surface.

The basic concept of Bergeron and Findeisen has been applied in the artificial rain making. In a cloud, silver dioxide or carbon dioxide is injected either by battery charging from the ground or by an aeroplane or rocket in the air. These particles when injected into a cloud act as freezing nuclei and account for rainfall. However, the making of artificial rainfall is expensive and in some cases the experiment may not yield desirable result.

2.3.11. Atmospheric disturbances

Atmospheric disturbances are the weather phenomena of great significance. Many such disturbances cause havoc in damaging properties and even life-forms on earth's surface. So these are sometimes referred to as climatic hazards which affect the habitat — both for human and other species.

The atmospheric disturbances may occur for several reasons. According to their genesis they are classed into different types of disturbances include :

(i) Thuderstorms and tornadoes, which mostly develop over the land surface as turbulent convectional storms.

(ii) Tropical storms, tropical cyclones, hurricanes or typhoons, which usually originate over the tropical seas and invade the coastal areas causing widespread damage over the land surface.

(iii) Mid-latitude or extra-tropical cyclones which result due to convergence of two contrasting air masses over the mid-latitude land surface around a centre of low pressure. Normally the mid-latitude cyclones are less severe than the tropical cyclones.

2.3.11.1. Thunderstorms

A thunderstorm is characterized by lightning and thunder and results due to intense convectional instability. Fundamentally, the thunderstorm is a thermo-dynamic machine in which the potential energy of latent heat of condensation and fusion in moist, conditionally and convectively unstable, air is rapidly converted into the kinetic energy of violent rising air associated with torrential rain, hail, gusty surface squall winds, lightning, thunder etc.

The thunderstorms are identified by chimneys of updrafts and downdrafts of air over a heated land surface. When the land surface becomes heated very fast, as in the summer months and noon hours of the day, air tends to rise vertically. Where the air is considerably moist or nearly saturated, the rising air will reach the dew points very shortly and at a lower height. After condensation the released latent heat will also act as a trigger for further rise of the air. The rise will continue until it reaches the freezing layer and afterwards the saturated air will move downwards with associated torrential rain, gusty squall winds, hails, lightening and thunder. Actually the rising air is related to the steepening of lapse rate under moist and convectible conditions. So the thunderstorms are caused by the processes which steepen the lapse rate. The intensity of thunderstorm depends on the supply of latent energy and the rate at which this energy is expended. A thunderstorm is therefore considered an intense instability outbreak.

2.3.11.2. Tornadoes

Tornadoes are unpredictable and deadly. They are so violent in the wind speed that twist everything with a cyclonic spin to a degree which stumps analysis and almost defies description. Hence in America the tornado is termed the twister. The term tornado has been derived from the Spanish word ***tronada***, which means thunderstorm.

Actually the tornado is associated with the development of an intense thunderstorm. As the updraft moves up in a large swells of rising warm air it rotates. If the rotation grows sufficiently intense, it can turn into a tornado or funnel cloud. Associated with the intense development of thunderstorm sometimes the base of the cumulonimbus cloud touches the ground surface as a trunk and tremendous suction results. The funnel cloud spins and moves along the ground for some distance with unusual wind velocity, even sometimes reaching upto 400 km per hour. Air rushing to fill in the void of low pressure creates additional fierce, potentially destructive winds. However, the extent of this funnel cloud or tornado is very limited — only 200-500 m in width and 15-25 km in length.

Most tornadoes form within a specific intense weather system known as supercell. Supercell thunderstorm develops when the warm updraft drives through an overlying stable layer and still rises upward into a zone of cool, dry air. In this way the resulting instabilities produce powerful vortex motion, the driving engine of the tornado.

The forecasting of the tornado is even today an impossible task and cannot minimize the risk of damage with suitable protection measures. Sometimes an updraft gives rise to tornado and sometimes it fails. The time to form a tornado from a thunderstorm is not more than a few ten minutes. So it provides little time for operational observation, identification and warning.

Tornadoes, though rare on a global scale, are found to occur in border areas of Orissa and West Bengal and in Bangladesh in hot summer season (March-May). A severe tornado hit Bangladesh on May 13, 1996 killing at least 500 and injuring more than 50000 people. In May, 1998 a tornado hit the Balasore district of Orissa and Midnapore district of West Bengal causing widespread damage including loss of human life. Tornadoes are also frequent in the central part of U.S.A., particularly from Kansas to Indiana states. On an average nearly 150 tornadoes develop in a year. These storms usually develop during the months of March, April and May between 14-00 hours to 22-00 hours. The following table indicates the occurrences of tornadoes in U.S.A. in the months of March, April and May in 1996.

Table 2.6. Deadly tornado statistics, U.S.A. (March-May, 1996)

Date	*Time*	*Location*	*Deaths*
March 6	04-01	W Selma, Alabama	4
March 6	05-15	Montgomery, Alabama	2
April 14	18-36	Alison, Arkansas	5
April 14	18-42	Sylamore, Arkansas	2
April 19	19-00	NR Ogden, Illinois	1
April 20	07-30	Carrollton, Massachussets	1
April 21	22-20	VanBuren, Arkansas	2
April 21	23-15	St. Paul, Arkansas	2
May 12	20-12	Okeechobee, Florida	1

Source : National Oceanic and Atmospheric Administration, U.S.A.

2.3.11.3. Tropical cyclone

The term cyclone was given to a rotating storm in the tropics by Piddleton. The name cyclone has been derived from a Greek word *cyclo,* which means the coil of a snake. These disturbances normally originate over warm tropical seas around a centre of low. This centre of low is usually formed in the months of May to September north of the equator ranging between 5-10^0N. Here the trade winds from both hemisphere converge at the equatorial low in summer months. This zone is called the Inter Tropical Convergence Zone (I.T.C.Z.). The position of I.T.C.Z. shifts and is related to the declination of the sun.

When the I.T.C.Z. becomes active the low pressure area develops. This low pressure area may turn to a depression, deep depression and ultimately to a severe cyclone. Based on thier intensity the tropical disturbances are classified as :

(i) Tropical disturbance — identified by one or no closed isobar, wind circulation poorly developed and velocity of winds weak.

(ii) Tropical depression — identified by one or more closed isobars, wind force equal to or less than Beaufort scale 6 (upto about 25 to 30 miles (40-50 km)/hour).

(iii) Tropical storms — identified by closed isobars and wind force in the range of Beaufort scale 6 to 12 (under 75 miles (120 km)/hour).

(iv) Hurricane or Typhoon — identified by intense low pressure, very steep pressure gradient and wind force greater than Beaufort scale 12 (over 75 miles (120 km)/hour). The severe cyclones which develop over the Caribbeans are called the Hurricanes and those developing over the Pacific ocean are called the Typhoons. Their characteristics are identical.

2.3.11.4 Cyclones over the Bay of Bengal and Arabian Sea

Each year cyclones and depressions form over the Bay of Bengal and Arabian sea and affect various parts of India, Bangladesh and Myanmar. Many of these storms turn violent and cause great havoc, damage properties and life. The following table will show the frequency of cyclonic storms over the Bay of Bengal and Arabian sea.

Table 2.7. Frequency of cyclones over Bay of Bengal and Arabian Sea

Month (Period 1891-1960)	*Bay of Bengal*	*Arabian Sea*
January	4(1)	2(0)
February	1(1)	0(0)
March	4(2)	0(0)
April	18(7)	5(4)
May	28(18)	13(11)
June	34(4)	13(8)
July	38(7)	3(0)
August	25(1)	1(0)
September	27(8)	4(1)
October	53(19)	17(7)
November	56(23)	21(16)
December	26(9)	3(1)
Total	314(100)	82(48)

The figures within brackets indicate the number of storms which reached severe intensity.

It appears that the number of storms over the Bay of Bengal is much greater than over the Arabian Sea. Three distinctive periods in a year can be identified for the occurrences of these storms and depressions in the Bay of Bengal and Arabian Sea. These periods are :

(i) The pre-monsoon period in the months of April and May.

(ii) The monsoon season covering the months of June, July, August and September.

(iii) The post-monsoon period in the months of October, November and December.

The period of January to March records very few storms — both over the Bay of Bengal and the Arabian Sea.

In the monsoon season the disturbances usually form in the north of Bay of Bengal and generally move in a north-westerly direction. The storms developing during this period are less severe, but contribute large rainfall over the coastal districts of Orissa, West Bengal and also inland areas of Bihar plateau and eastern Madhya Pradesh. On the other hand, the distrubances in the pre-monsoon and post-monsoon seasons develop in different regions of the Bay of Bengal and move in various directions. The tracks of many of these disturbances undergo recurvature. In general these storms are violent and cause widespread damages over the coastal areas of Andhra Pradesh, northen Tamilnadu, Orissa, West Bengal and sometimes coastal districts of Bangladesh and Arakan coast of Myanmar.

These tropical cyclones cause damages in three ways :

(i) The storm surge with an abnormal rise of sea level resulting in inundation of the coastal areas.

(ii) High velocity stormy winds that damage buildings and other structures.

(iii) Heavy rain that gives rise to flooding and water logging of vast area. This results in destruction of standing crops in the fields.

Hurricanes in the Caribbean Sea and North Atlantic : The hurricanes over the Caribbean sea and North Atlantic ocean commonly develop in summer months, particularly during August-September. According to the National Hurricane Center of the U.S.A. on an average 9 storms develop over the Caribbean sea and North Atlantic Ocean of which 6 turn to be the hurricanes. These hurricanes every year cause damage to properties and life in the Central American Island states and south eastern littoral areas of United States of America. The hurricane named 'Mistral' devastated large areas of Central America and south eastern coastal U.S.A. in 1998. It has been termed as one of the worst environmental hazards of the 20th century.

2.3.11.5. Mid-latitude cyclones

In the mid-latitude region close to the sub-polar low region two contrasting air masses, namely cold polar (cp) and maritime tropical (mt) air masses converge. These air masses build along their margin fronts, which ultimatley develop into a mature cyclone.

The cyclone model was illustrated by J. Bjerkness in 1937 and is known as Polar Front theory. In this model, at the initial state, the cold airmass of polar origin and warm airmass of tropical oceans form a line of separation between the two along a low pressure centre. The temperature contrasts result in the development of wind shear and also wind shift. As a consequence there will be rising light warm air, pushed back as wedge from the rear by cold heavy air. Hence two fronts are formed — cold front and warm front — having distinctive characteristics. The cold front is more active and faster than the warm front in movement. The warm front is ultimately overwhelmed by the cold front, when there will be formation of occluded front. The occluded front will indicate the decay of the cyclone.

2.3.11.6. Western disturbances

The western distrubances are typical weather phenomena, observed in north and northwestern India in winter and late winter months. These disturbances develop over the Atlantic Ocean and Mediterranean Sea close to Spain and move further east through Asia Minor. These depressions become weaker over the land surface, but after entering north and north-west India they turn active. These depressions contribute winter rainfall in Jammu and Kashmir, Punjab, Haryana, Uttar Pradesh and even in north Bihar, West Bengal, Assam and Arunachal Pradesh.

In western disturbances we observe the prevalence of occluded front. The cold and warm fronts are weaker in western disturbances. Drizzles or light showers are associated with the warm front, afterwards the weather becomes clear for a short period. Thereafter heavy showers along with thunder rain follow along the cold front. Afterwards the temperature drops markedly and the region comes under the influence of cold wave from rear. Associated with the invading western disturbances ground fogs develop for a longer duration in the morning hours and cause very poor visibility. However, the winter rainfall and snowfall (in the hills) contributed by winter disturbances are beneficial for wheat farming in north and north-west India.

2.4. Natural cycles

Different natural cycles can be identified on earth. These cycles play significant role in maintaining a balance in the lithosphere, atmosphere and biosphere. Of these we can mention a few of great interest. These are namely :

(i) Hydrologic cycle

(ii) Geologic cycle or Earth recycle,

(iii) Bio-geochemical cycle, e.g. Carbon cycle, Nitrogen cycle, Oxygen cycle, Sulphur cycle, Phosphorus cycle etc.

2.4.1. Hydrologic cycle

The hydrologic cycle is the source of fresh water on earth's surface on which depend most of the living species. We have discussed the hydrologic cycle in Section 2.2.3. and also in Chapter V under Section 5.3.2. In this Section we will discuss the other cycles.

2.4.2. Geologic cycle

The geologic cycle, first proposed by Hutton, is sometimes referred as the recycling of the earth.

From the evidences of ***plate tectonics*** and development of ***mantle convection model,*** it is argued that the earth's surface and the interior processes are intimately linked. The earth appears to be a gigantic machine that creates and destroys lithosphere as it loses internal heat slowly. As a result some portions of the earth rise as a consequence of plate interactions and in some places there are depressions.

Since the formation of the earth the agents of weathering and erosion had been continuously acting upon the earth's surface. These agents actively denuded the land surface and carried the sediments to the margin of continents in the marginal seas adjoining the plates, called ***tethys***. These are the structurally weak zones of the earth's surface, known as ***geosynclines.***

Deposition of huge amount of sediments would occur in such subducted zones. The buried sedimentary particles would in turn be transformed into hard sedimentary rocks and exert pressure to cause the plate motions. There would be resultant folding leading to the rise of lofty mountains. It is understood that all the mountains in the geological past might have risen due to such tectonic activities. After the rise of the land surface the processes of weathering, erosion, denudation, deposition of sediments in the subducted zone etc. would be renewed. In this way the relief of the earth surface is recycled. The potential energy essential for the transport of sediment particles is finally provided by the mantle heat by way of the motions of lithospheric plates.

Rock cycle : The rock cycle is another form of geologic cycle related to the formation of rocks in the lithosphere. The sequential change of rocks from one type to another is called the rock cycle. The earth's crust was initially formed of igneous or primary rocks, due to cooling of magma and molten lava, erupted from the interior of earth. These igneous rocks, where exposed on earth's surface, were subject to weathering and erosion for a long time. Due to such processes large amount of detritus materials were generated and carried over by rivers, winds and deposited in shallow seas and lakes. These deposited sediments were later cemented and compacted to form sedimentary rocks. It may also be noted that weathering and erosion of sedimentary rocks in later geological period also contributed to sedimentation and formation of sedimentary rocks by similar processes. Both the igneous and sedimentary rocks were agian transformed into metamorphic rocks due to excess pressure and high temperature conditions. Tremendous pressure or stress was exerted due to orogenic movements and high temperature conditions that prevailed at the time of volcanic or tectonic movements.

Metamorphic rocks penetrating inside the earth were again subjected to very high temperature conditions prevailing there and melted. Such melting would result in flow of magma, which being cooled form igneous rocks. The process repeats and the cycle is complete. This is sometimes referred to as geologic cycle, as it is related to geologic processes.

2.4.3. Biogeochemical cycles

All living species are composed of matter and over all the organisms require about 40 chemical elements for life processes and growth. Those elements needed in large amounts are called the ***macronutrients***, and those required in trace amounts are known as ***micronutrients***. The macronutrients belong to two groups — i) those nutrients constituting more than 1 percent each of dry organic weight such as carbon, oxygen, hydrogen, nitrogen, and phosphorous, ii) those nutrients constituting 0.2 to 1 percent of dry organic weight such as sulphur, chlorine, potassium, sodium, calcium, magnesium, iron, and copper. Micronutrients constitute less than 0.2 percent of dry organic matter. But many micronutrients may not be present in all species — these include elements like aluminium, boron, bromine, chromium, cobalt, fluorine, gallium, iodine, manganese, molybdenum, selenium, silicon, strontium, tin, titanium, vanadium and zinc. The flow of these nutrients in the ecosystem is cyclic and they are transferred from one trophic level to the other and ultimately released in the ecosystem for recycling. This is therefore the cycle of chemical elements involving biological organisms and their geographical environment (atmosphere or lithosphere). Hence the cycle is referred as ***biogeochemical cycle.***

The biogeochemical cycles are of two types — i) ***gaseous cycle*** and ii) ***sedimentary cycle***. The gaseous cycles occur where the atmosphere constitutes the major reservoir of the elements that exist in gaseous state. Carbon, nitrogen and oxygen cycles represent the gaseous biogeochemical cycles. On the other hand, the sedimentary cycles are evidenced where the sediments in lithosphere constitute the major reservoir from which the elements are released by the process of weathering. Of the different sedimentary cycles the sulphur and phosphorus cycles are of great significance to the biosphere.

2.4.3.1 Carbon cycle

The carbon cycle (Figure 2.1) is very important for conversion of radiant energy into chemical energy (C-C bonds of carbohydrates) in the plants by the process of photosynthesis. In the process carbon dioxide is absorbed by the plants from the atmosphere, which remains the storehouse of carbon dioxide. Carbon dioxide is released to the atmosphere by various means — by respiration of the plants and animals and burning of the fossil fuels. The respiration by plants and animals releases about 60 billion tons of carbon dioxide, which is exactly balanced through the process of photosynthesis by plants. The fossil rocks contain a vast store of carbon (40,000 billion tons). The burning of fossil fuels releases nearly 6 billion tons of carbon dioxide annually. An estimated 6 billion tons of carbon dioxide is thus added to the

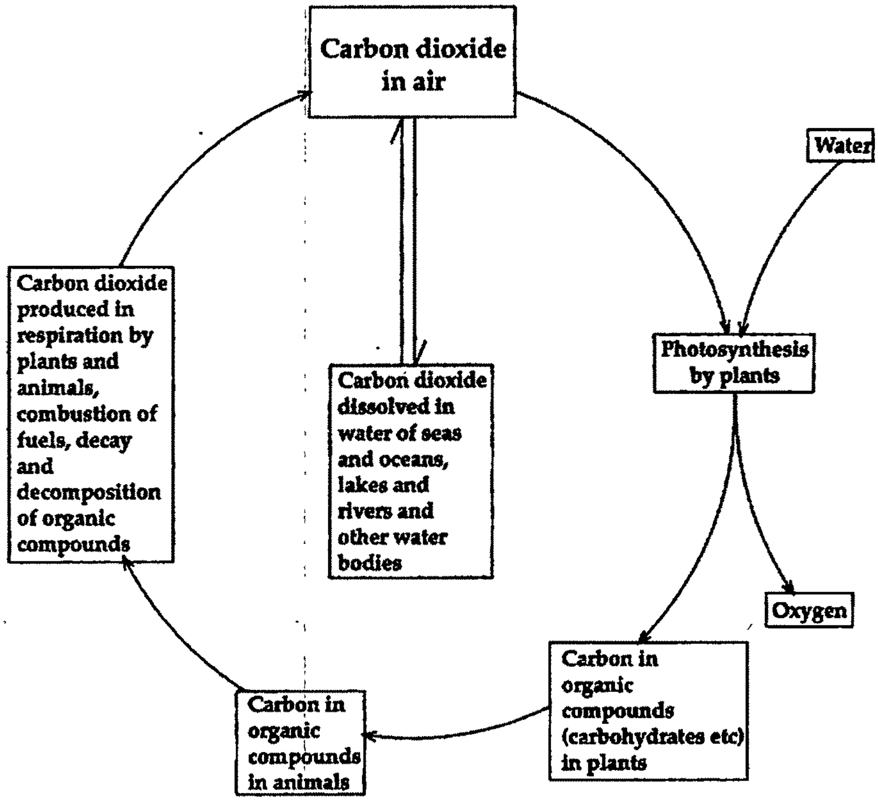

Carbon dioxide in air
Water
Photosynthesis by plants
Oxygen
Carbon in organic compounds (carbohydrates etc) in plants
Carbon in organic compounds in animals
Carbon dioxide produced in respiration by plants and animals, combustion of fuels, decay and decomposition of organic compounds
Carbon dioxide dissolved in water of seas and oceans, lakes and rivers and other water bodies

Figure 2.1. Carbon Cycle

atmosphere each year. The amount of carbon dioxide is only 0.035 percent by volume of the constituent gases in the atmosphere, the estimated total amount, however, comes to about 23 billion tons. Carbon dioxide is also released when some carbon compounds are decomposed by microorganisms.

Another important regulatory role is played by the oceans in the exchange of carbon dioxide. The oceans form the largest reservoir of carbon dioxide containing nearly 130,000 billion tons of carbon dioxide, i.e. are 50 times more than the atmosphere. There is an exchage of 200 billion tons of carbon dioxide between the oceans and the atmosphere each year. Carbon dioxide is dissolved in the ocean water to form carbonic acid, which converts carbonates into bicarbonates. The bicarbonates are dissociated during photosynthesis to precipitate carbonate.

The carbonate rocks in the lithosphere also have small reserve of carbon dioxide — amounting the only 0.1 billion tons of carbon dioxide. This amount of carbon dioxide (0.1 billion tons) is absorbed by the rocks through weathering process.

It can be seen from the following table that the natural gain of carbon dioxide by the atmosphere from different sources in exactly balanced by the natural loss, except the additions contributed by human action thorough burning of fossil fuels and cultivation of soils.

Gain by the atmosphere (billion tons)	Process
2	Released from the soils by cultivation
6	Burning of the fossil fuels
0.1	Released from the hot springs and volcanoes
60	Respiration and biological decomposition
100	Released from the oceans
Loss from the atmosphere	
0.1	Weathering of the rocks
60	Photosynthesis by the plants
100	Absorption by oceans

Hence the net gain by the atmosphere is estimated at 8 billion tons (6 billion tons from burning of fossil fuels and 2 billion tons released from soils). This creates imbalance in the status of carbon dioxide in the atmosphere and has contributed largely to the green house effect and global warming and consequent climatic change.

2.4.3.2. Nitrogen cycle

The nitrogen cycle (Figure 2.2) in general resembles the carbon cycle, but differs in some respects. The nitrogen cycle is more complex than the carbon cycle. Nitrogen is the source of proteins and nucleic acids and in that sense it is essential for life. Atmosphere is the

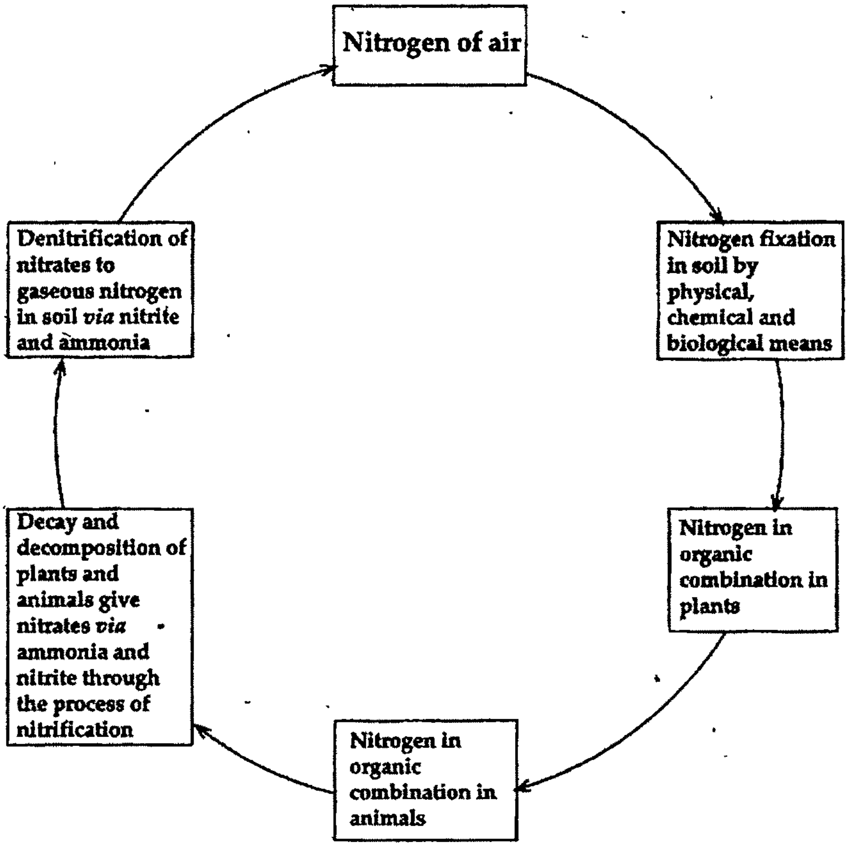

Nitrogen of air
Nitrogen fixation in soil by physical, chemical and biological means
Nitrogen in organic combination in plants
Nitrogen in organic combination in animals
Decay and decomposition of plants and animals give nitrates *via* ammonia and nitrite through the process of nitrification
Denitrification of nitrates to gaseous nitrogen in soil *via* nitrite and ammonia

Figure 2.2. Nitrogen Cycle

reservoir of free gaseous nitrogen as it constitutes nealy 78 percent of the atmosphere by volume. Nitrogen as compound also resides in the bodies of living organisms and in the soils. But free nitorgen cannot be utilized directly by the organisms, with the exception of few nitrogen-fixing bacteria and blue green algae.

As mentioned the nitrogen cycle being a complex one, gaseous free nitrogen in the atmosphere is converted into ammonia or oxidized to nitrate forms at different stages. Nitrogen-fixing bacteria and blue-green algae play significant role in converting the gaseous nitrogen into organic compounds and finally to nitrates soluble in water. Nitrates are utilized by plants for the synthesis of amino acids and proteins. The plant proteins are consumed by the herbivores, which convert them into their tissues. When the plants and animals die or their remains are decomposed by various organisms, the nitrogen is again released in the atmosphere.

The steps in the nitrogen cycle are : nitrogen fixation — ammonification — nitrification — denitrification — release of gaseous nitrogen.

Nitrogen fixation is done by i) non-biological or electrical methods, and ii) biological methods. Thunderstorm and lightning play a significant role in producing nitrates by non-biological or electrical methods. Blue-green algae like ***Anabaena, Nostoc*** and ***Oscillatoria*** fix nitrogen by biological methods. Many free-living bacteria can also fix nitrogen — both non-symbiotically and symbiotically. Of the non-symbiotic nitrogen-fixing bacteria ***Clostridium, Azotobacter,*** and ***Derxia*** are important. ***Rhizobium*** living in root nodules of leguminous plants can fix nitrogen symbiotically.

Ammonification is the process in which nitrogen in organic matter of dead plants and animals is converted to ammonia and amino acids.

In the nitrification process ammonia is first converted into nitrites by a group of microorganisms like ***Nitrosomonas, Nitrospira, Nitrosogloea*** and ***Nitrococcus.*** Nitrites are then converted to nitrates mostly by ***Nitrobacter*** and ***Nitrocystis.***

Denitrification is the process in which ammonia and oxides of nitrogen are reverted back to nitrogen by different forms of bacteria, namely ***Bacillium cereus, B. licheniformis*** and ***P. denitrificans.*** The gaseous nitrogen is released to the atmosphere and the cycle continues.

2.4.3.3. Oxygen cycle

The oxygen cycle (Figure 2.3) is a relatively simple one. Oxygen constitutes nearly 21 percent of the atmosphere by volume. Oxygen is also present in water and rocks in combined form. Free oxygen in air is essential for living animals to breathe, whereas the aquatic animals get their sustenance from the dissolved oxygen (DO). The status of oxygen is exactly balanced in the atmosphere. The green plants assimilate carbon dioxide in photosynthesis and release oxygen from water to the atmosphere. So the air becomes fresh. The plants and animals use

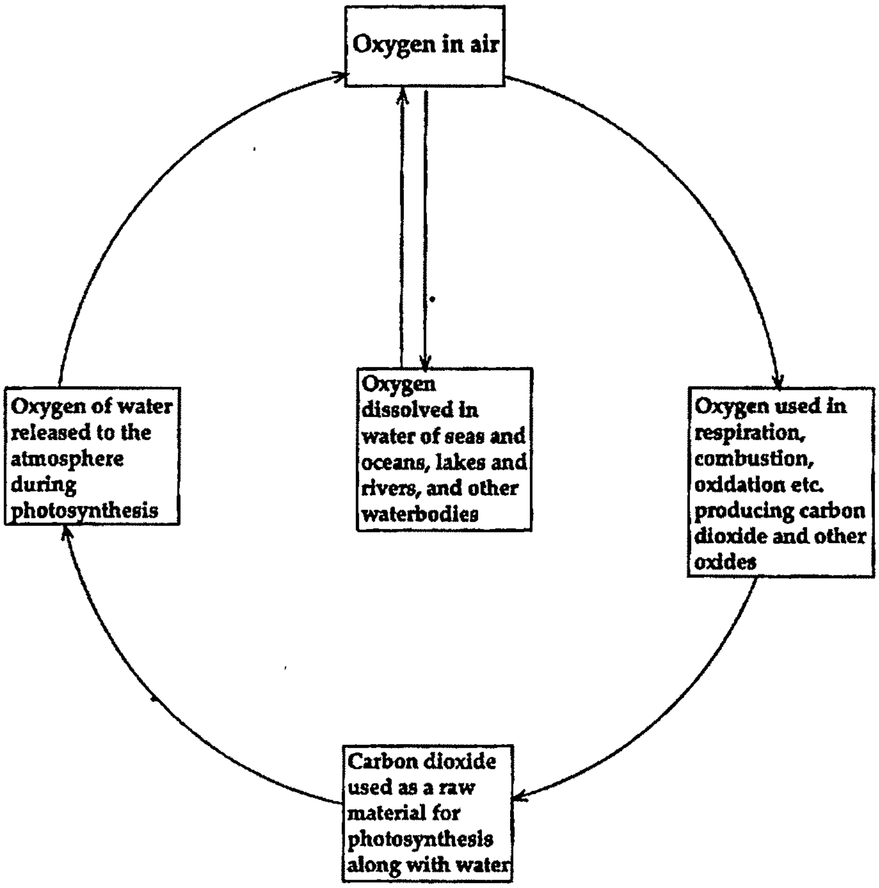

Oxygen in air
Oxygen dissolved in water of seas and oceans, lakes and rivers, and other waterbodies
Oxygen used in respiration, combustion, oxidation etc. producing carbon dioxide and other oxides
Carbon dioxide used as a raw material for photosynthesis along with water
Oxygen of water released to the atmosphere during photosynthesis

Figure 2.3. Oxygen cycle

oxygen of the air in respiration and release carbon dioxide that is actually balanced by the uptake of carbon dioxide and the release of oxygen by green plants in photosynthesis.

2.4.3.4. Sulphur cycle

Sulphur may be present in the atmosphere in the form of sulphur dioxide and hydrogen sulphide, but such phase is very short lived. Sulphur is mostly derived from organic matter, which being decomposed and mineralized yields inorganic sulphate. The living and dead organic matter through combustion also add sulphur dioxide to the atmosphere. However, the inorganic sulphate is the principal source of biologically significant sulphur. The biologically formed sulphydryl sulphur (-SH) is mineralized by bacteria and fungi (species like ***Aspergillus*** and ***Neurospora***). Under anaerobic conditions some of these may be reduced to sulphides, including hydrogen sulphide by bacteria like ***Escherichia*** and ***Proteus***. Sulphate is also reduced under anaerobic conditions to elemental sulphur or sulphides, including hydrogen sulphide by species like ***Desulfavibrio, Escherichia*** and ***Aerobacter***. Sulphides and sulfur may be converted to inorganic sulphate. Thus the sedimentary cycle of sulphur is complete. On the other hand, the inorganic sulphates are assimilated by the roots of the plants and transferred to cellular organic matter. By combustion of the organic matter sulphur dioxide is returned to the atmosphere. Different forms of sulphides, including hydrogen sulphide also contribute to atmospheric sulphides. During rains the atmospheric sulphur dioxide and sulphide become precipitated in the soil and are available for circulation. In this way the interactions between air, water and sediments make possible the natural cycling of sulphur (Figure 2.4).

2.4.3.5. Phosphorus cycle

Phosphorus is a constituent of nucleic acid, phospholipids, and numerous phosphorylated compounds. As such, it is important for biological systems. Unlike sulphur, phosphorus has no gaseous stage, though it may often be found as tiny solid particles in the atmosphere. Plants usually take inorganic phosphate for their nutrition, the phosphate is then transferred to consumers and decomposers as organic phosphate. Thereafter it is converted to inorganic phosphate through mineralizing decomposition. The water soluble phosphate is also available in the aquatic system.

Phosphorus is temporarily lost from the cycle by physical processes and also by biological processes. Phosphorus is adsorped by sediments and soils. The sediments are later concentrated in the lakes or other aquatic systems. The formation of teeth and bone in animals require phosphorus, but as these are very resistant to weathering, phosphorus is apparently lost from the cycle. Similarly the excretion also account for the loss of phosphorus from the biotic portion of the cycle.

The pattern of the phosphorus cycle (Figure 2.5) though similar to the other nutrient

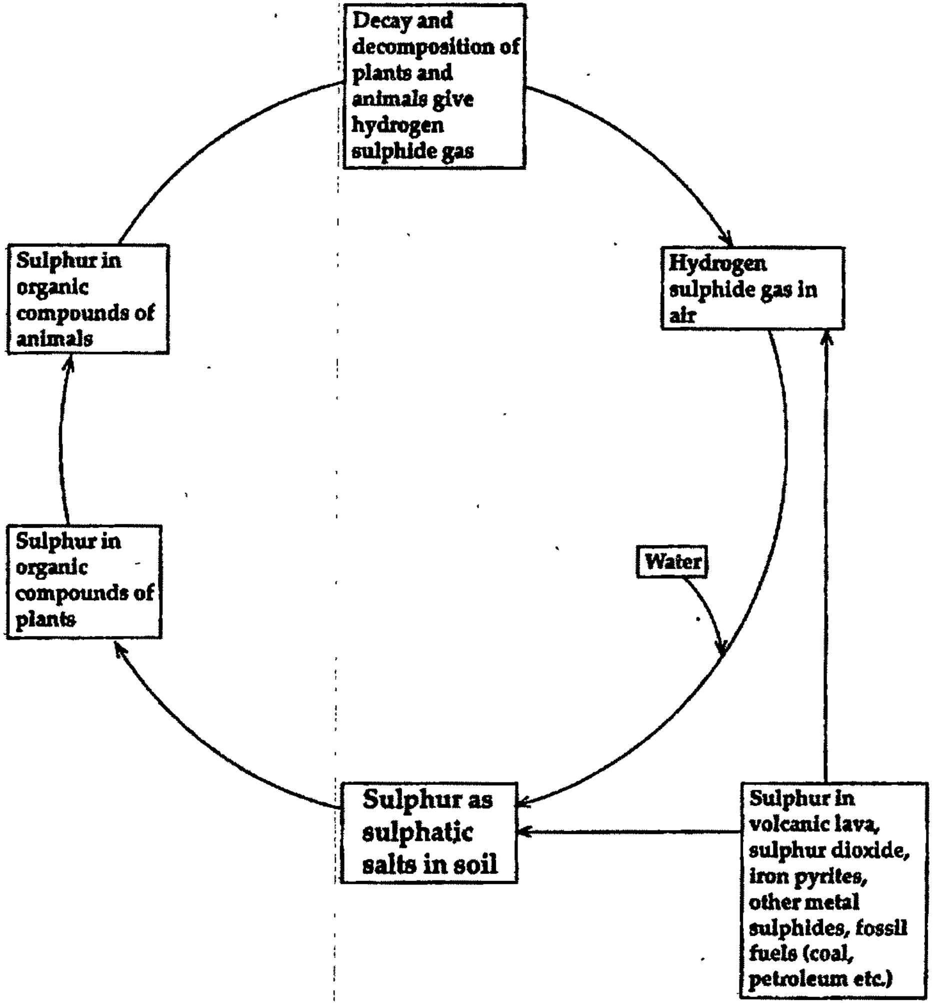

Decay and decomposition of plants and animals give hydrogen sulphide gas
Hydrogen sulphide gas in air
Water
Sulphur in volcanic lava, sulphur dioxide, iron pyrites, other metal sulphides, fossil fuels (coal, petroleum etc.)
Sulphur as sulphatic salts in soil
Sulphur in organic compounds of plants
Sulphur in organic compounds of animals

Figure 2.4. Sulphur Cycle

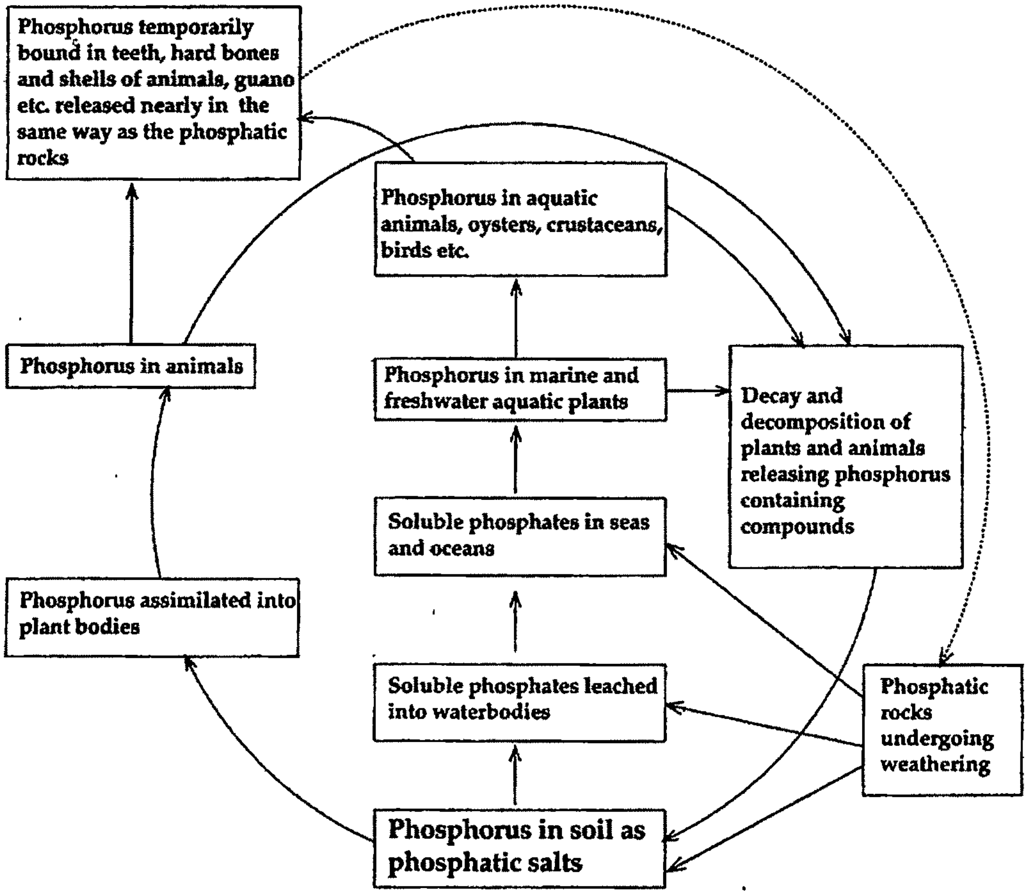

Phosphorus temporarily bound in teeth, hard bones and shells of animals, guano etc. released nearly in the same way as the phosphatic rocks
Phosphorus in aquatic animals, oysters, crustaceans, birds etc.
Phosphorus in animals
Phosphorus in marine and freshwater aquatic plants
Decay and decomposition of plants and animals releasing phosphorus containing compounds
Soluble phosphates in seas and oceans
Phosphorus assimilated into plant bodies
Soluble phosphates leached into waterbodies
Phosphatic rocks undergoing weathering
Phosphorus in soil as phosphatic salts

Figure 2.5. Phosphorus Cycle

cycle is significantly characterized by stagnation. So the phosphorus cycle and the deposition of phosphorus can be better understood in a particular ecosystem, rather than in a global circulation pattern. Phosphorus cycle, particularly in the aquatic ecosystem follows three distinct phases : inorganic phosphorus — particulate organic phosphorus — dissolved organic phosphorus — inorganic phosphorus. On the other hand, some of the dissolved and soluble phosphates are deposited as shallow marine sediments. These sediments give rise to the formation of phosphatic rocks. The remains of dead aquatic animals and marine organisms often form fossil bone deposits and excreta of birds yields guano deposits rich in phosphorus. From the eroded phosphatic rocks, fossil bone deposits and guano deposits, dissolved phosphates are again available in the aquatic or marine system. However, there has been a loss of phosphates from shallow marine deposits to deep sediments.

CHAPTER III

ECOSYSTEM

3.1. Ecology and concept of ecosystem

The term ecology is now widely used. It is derived from the Greek roots ***oikos*** (meaning home) and ***logos*** (meaning study or discourse) which imply study of organisms 'at home'. There is uncertainty about the first coinage of the term. Probably, Henry David Thureau in 1858 first used this term. Subsequently, German Biologist Hanns Reiter in 1865 also used this term but without any definition. The credit of precisely defining ecology goes to another celebrated biologist Ernst Haeckel. In 1870, he defined ecology as the "scientific study of the relationships of living organisms with each other and with their environments".

In ecology, the term population is used to denote groups of individuals of any one kind of organism. Likewise, 'community' includes all of the populations occupying a given area. The term 'ecosystem' was first proposed by the British ecologist Tansley in 1935. The living organisms or community (biotic) and their nonliving (abiotic) environment function together as an ecological system or ecosystem. Hence, ecosystem may be defined as a functional unit where the biotic and abiotic components of the environment interplay in such a manner that through it flow of energy and matter takes place. The community with all the plants and animals forms the biotic component, while the organic and inorganic substances together with climatic factors constitute the nonliving or abiotic component of the ecosystem.

3.1.1. Abiotic and biotic components of ecosystem

The earth upon which we live may be considered a vast ecosystem. The portion of the earth in which the biotic components are present is called the biosphere or ecosphere which obtain energy from the sun. The earth comprises the soil, water and air which are nonliving (abiotic) materials but provide sustenance to the vast array of living forms.

From the nutritional (trophic) standpoint, an ecosystem has two components such as (a) ***autotrophic*** component (autotrophic means self-nourishing) in which the organisms fix light energy and utilize substances like carbon dioxide and water to produce complex food materials, and (b) ***heterotrophic*** component (heterotrophic means 'other-nourishing in which the organisms utilize, rearrange and decompose the complex materials synthesized by the autotrophic components.

From a structural standpoint, six components are recognized as comprising the ecosystem. These are : ***(i) inorganic substances,*** such as carbon, nitrogen, carbon dioxide, water etc., ***(ii) organic compounds,*** such as proteins, carbohydrates, lipids, humic substances etc., ***(iii) climatic conditions,*** such as temperature, soil and other physical factors. These three items form the abiotic components of the ecosystem. The three items, constitute the biotic components of the ecosystem : *(iv) producer components*—these are autotrophic organisms, generally green plants which are able to manufacture food from abiotic elements carbon dioxide, water, nitrogen etc., *(v) macroconsumers* or *phagotrophs* (phago means 'to eat')—this includes relatively big heterotrophic organisms, largely animals which ingest other organisms or food synthesized by the producers, and *(vi) microconsumers* or *saprotrophs* - these are heterotrophic usually microscopic organisms like bacteria and fungi which break down and decompose the complex substances of dead organisms (producers and macroconsumers), absorb the decomposition products and release inorganic nutrients for reuse by the producers.

Ecosystem has great importance because maintenance of equilibrium in the environment is performed by the system which operates through feedback mechanisms. If the stabilized system is disturbed, lots of environmental anomalies develop which adversely affect the biosphere including mankind. The steady state or dynamic equilibrium condition of the ecosystem would persist and sustain itself if there is no human intervention.

3.1.2. Biomes

The biome is the largest recognizable land community unit. In a given biome, the life-form of the regional climatic climax is uniform. Thus the climax vegetation of the grassland biome is uniform. Actually, biomes may provide a sound basis of natural ecological classification, because the nature of the vegetation of one region reflects the major features of the climate as well as the habitat.

The principal biomes of the world are the Tundra, Temperate, Coniferous Forest, Temperate Deciduous Forest, Temperate Grassland, Tropical Savanna, Desert, and Tropical Rain Forest.

(i) **The Tundra Biome** : Tundra lies north of latitude 60°N(i.e. between the Arctic ocean and polar ice caps) and is characterized by the absence of trees, the presence of dwarfed plants, and an upper ground surface that is wet, spongy and uneven as a result of freezing and thawing of this poorly drained land. The most characteristic tundra plant is the lichen known as 'reindeer moss' (*Cladonia* sp.) which is actually a symbiotic association of a fungus and an alga. The animals are reindeer, the arctic hare, arctic fox, polar bear, wolves and a host of migratory birds.

(ii) **Temperate Coniferous Forest Biome :** Adjacent to the tundra region is the temperate coniferous or boreal forest. These are cold regions with high rainfall, with long winters and short summers and are characterized by boreal coniferous forest which is transcontinental. Such forest is dominated by spruce (*Picea glauca*), fir (*Abies balsamea*) and pine (*Pinus resinosa, Pinus strobus*) trees and by animals like snow hare, the lynx, the wolf, bear, red fox, squirrels etc., and amphibians such as *Hyla, Rana* (frog) etc.

(iii) **Temperate Deciduous Forest Biome :** This is characterized by a moderate climate and broad-leaved deciduous trees, which shed their leaves in autumn, are bare over winter and grow new foliage in spring. In India, at elevations of 3000-4000 m in the Himalayas occur temperate deciduous vegetation including pines, fir and juniper trees with an undergrowth of rhododendrons. The animals present in temperate deciduous forest are deer, bears, fox, mountain lions, turtles, lizards, snakes, horned owls and hawks.

(iv) **Temperate Grassland Biome :** The grassland.biome is found where rainfall is about 25 to 75 cm per year, not enough to support a forest, yet more than that of a true desert. Grasslands occur in the interior of continents and include tall grass prairies, short grass prairies of North America, as well as the steppes of southern Russia, Siberia and Asia, the veldt of Africa and the pampas of South America. Grasses growing on grasslands can be divided into two basic groups, the tall grasses and the short grasses while the typical animals tend to be rather small in size. Rodents such as prairie dogs, rabbits and ground squirrels are common. The characteristic birds of grassland are prairie chicken, meadow larks and rodent hawks. The common insects of steppes are termites, locusts and bees. Lizards and snakes are also met with in large numbers.

(v) **Tropical Savanna Biome :** Savanna are tropical grasslands with scattered, drought-resistant trees; generally not exceeding 10 m in height and do not form a canopy. Thus a savanna is an intermediate between a forest and grassland. Savanna constitute extensive areas in eastern Africa, Australia and South America, which support the richest diversity of grazing mammals. Large herbivorous animals like elephants, wild buffaloes, giraffes, zebras, wildebeests, antelopes as well as the predators like lions and leopards are found in the African Savanna.

(vi) **Desert Biome :** Desert biomes are formed in extremely dry environments. The temperature may range from very hot as in hot deserts to very cold as in cold deserts. Major hot deserts of the world are situated near the Tropics of Cancer and Capricorn with annual rainfall of less than 10 mm. Cold deserts occur in extremely cold and dry regions in which drought conditions cause adaptive modifications of plants through reduced leaf size and succulence. The animals present in the arid desert biomes are reptiles, insects and burrowing rodents such as desert rats.

(vii) **Tropical Rainforest Biome :** Tropical rainforests occur near the equator and are among the most diverse communities on earth. Here both temperature and humidity are high and nearly constant. The annual rainfall which exceeds 200-225 cm is evenly distributed throughout the year. The extremely dense vegetation of the tropical rainforests is comprised of tall trees often covered with vines, creepers, lianas, epiphytic orchids and bromeliads. Under the tall trees is a continuous evergreen carpet composed of herbs and shrubs. Invertebrate animal density and abundance are very high in tropical rain-forests where diverse types of vertebrates are also present.

3.2. Ecosystems of the world

The ecosystems of the world may be studied in terms of particular habitats in which these predominate. This gives us an idea about the organisms and physical factors actually associated with a particular ecosystem. There are three major habitats in the geosphere, viz. lithosphere (land or terrestrial) hydrosphere (marine, fresh water, aquatic and wet land) and atmosphere. It may be mentioned that atmosphere does not have any permanent inhabitant. Both lithosphere and hydrosphere have a wide variety of flora and fauna.

3.2.1. Land based ecosystem

Of the major environmental components, land is considered to be the most variable in terms of age, topography and structure. Land (terrestrial) ecosystems are largely determined by the climate (temperature, moisture, light etc.) and the substrate (soil).

Higher plants and animals have developed on land. These include the seed plants, the insects, the warm-blooded vertebrates which are dominant on land today. A growing human population exerts a great impact on the terrestrial ecosystem. The microorganisms belonging to the lower groups from the evolutionary standpoint also play a significant role.

The large rooted green plants are present on land. These green plants manufacture food, provide shelter for other organisms and play a vital role in holding and modifying the earth's surface. These are the basic producers of the land and are autotrophs requiring only light and inorganic nutrients. Land plants, however, may depend on other microorganisms for their nutrition, as we have seen in the symbiotic mycorrhizae and symbiotic bacteria (in root nodules of leguminous plants). Mycorrhiza is the symbiotic association between a fungus and the roots of a plant. The plant is able to draw the mineral nutrients from the soil made available by the fungus which in turn derives the carbohydrate supply from the plant. The situation is almost similar in case of symbiotic bacteria. The major terrestrial communities include several life-forms like herbaceous plants, shrubs and grasses and woody trees. Another classification refers to adaptations along environmental gradients, viz., hydrophytes (wet), mesophytes(moist), xerophytes(dry) and halophytes (salt). The variety and abundance of insects and other arthropods is another important feature of terrestrial communities. Another very conspicuous group represented by birds of numerous species and varieties is found in almost every land community.

3.2.2. Marine ecosystem

Oceans cover three-fourth portion of the earth's surface, harbouring a vast variety of plants (mainly algae),animals like zooplankton, shrimps, crabs, oysters, krills, fishes, reptiles, birds and mammals. This system also receives a huge quantity of run-off materials and wastes from terrestrial systems directly from coastal regions and indirectly by rivers from distant inland regions.

Marine water has a high salt content of about 3.5% by weight. Fertility status of marine water is poor as compared to fresh water which contains dissolved nitrates and phosphates.

The marine ecosystem is the entire region extending from the coastal land visited by tides to the deepest zone in the open sea. It can be divided as follows :

(i) The supratidal belt—the region in the sea coast upto which the high tides just reach submerging the land and plants thereon.

(ii) The intertidal belt — this zone extends from subtidal to supratidal zones, i.e., the region which is periodically covered by sea water.

(iii) The neritic zone — this is the shallow coast line belt that is flat in most part and abruptly drifts down to deeper zone. It receives enough light and bears diverse kinds of marine vegetation, those growing on bottom rocks are called benthic and those that occur in water above as pelagic. This marine belt is sometimes called littoral.

(iv) The euphotic zone — this zone refers to the upper layer of water in continuation from shallow shoreline to the far off oceanic belt, where light is abundant.

(v) The dysphotic and aphotic zones — these are zones where light is insufficient (dysphotic zone) or where there is no light (aphotic zone).

(vi) The oceanic belt - the zone of sea far away from land is called oceanic belt. The top 100-200 m layer is euphotic zone. From' 200 m to about 2000 m is called the bathyal zone. Very deep and dark zone of water below 2000 m is called abyssal zone which is free of any photosynthetic organisms. Primary producers and consequently herbivores are absent here because of lack of light.

In the oceanic belt, life is concentrated in the euphotiç zone, where both the macroplankton and microplankton are the main primary producers on which big fishes flourish. In the shore line or in the continental shelf, the marine life is most abundant and the diversity of flora and fauna is very high. There are some fauna that dig narrow holes in the bottom and are called infauna and there are others that live on the surface either attached or free moving and are called epifauna. Commercial fishes are also abundant in this region. Other important animals are large sea mammals like whales and seals. Pearl harvest and pearl culture is an important commercial activity dependent on marine ecosystem.

3.2.3. Freshwater ecosystem

Freshwater bodies contribute a very small (only 3%) fraction of total area of water, but from the point of view of human use these are among the most important natural water resources. Freshwater bodies are of various sizes and depths. They are either surrounded by land from all sides and the water, therefore, is stationary, or lentic (lentis means calm), as in a land-bound lake or floating water body (open on two ends and land-bound on the other two sides) like rivers, streams etc. representing flowing or lotic water (lotus means washed). These two types or water bodies differ in their ecological nature because of replacement of water in lotic water due to its flowing nature, and of non-replacement or almost permanent nature of lentic water in ponds, lakes, etc.

Like marine ecosystem, a similar classification of freshwater ecosystem can be made on the basis of depth, light penetration and temperature condition.

(i) **Photic stratification** : The level of illumination in a water body is dependent on the depth of water column and the clarity of water. On the basis of illumination, the freshwater ecosystem is divided into three zones, namely littoral, limnetic and profundal zones. Littoral zone is on the margin of lake with shallow depth. Plants like ***Typha sp, Eliocharis sp.*** and ***Cyperus sp.*** grow on the margin. Free floating and rooted plants with floating leaves such as ***Lemna*** (khudipana), ***Azolla*** (postapana), ***Nymphaea*** (shaluk) and ***Nelumbium*** (padma) grow further away from the margin. Submerged plants like ***Vallisnaria, Ottelia*** and ***Potamogeton*** also occur in this zone. Here phytoplankton and zooplankton are also found. Limnetic zone refers to an open expanse of water from surface to only as much depth as is illuminated, sufficiently to cause photosynthesis. This zone is rich in phytoplankton, large floating algae and macrophytes which produce enough oxygen through photosynthesis suitable for good growth of fishes. On the basis of light penetration, both littoral and limnetic zones are euphotic. Here light penetration is either minimum (dysphotic) or totally absent (aphotic). Profundal zone is the lowest zone found in deep lakes. It refers to the depths ranging from the limnetic layer downwards up to the bottom. The primary producers or the green plants cannot grow here, because light is not sufficient for photosynthesis. Instead, the dead plant and animal bodies sink and become the food substrate for decomposer organisms like bacteria and fungi. Fishes that eat dead remains of plants and animals also occur here.

(ii) **Thermal stratification** : On the basis of temperature variations in the vertical column of water, three zones in a lake ecosystem are (a) upper warm epilimnion (epi — upper, limnos — lake), (b) middle transitional or intermediate thermocline, and (c) lower cold water zone, the hypolimnion.

3.2.4. Wetland ecosystem

Wetlands form a valuable natural ecosystem bringing benefits to people. These harbour a wide variety of plants, animals and microorganisms. Wetlands are ecotones (lands transitional between terrestrial and aquatic systems) where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands, at least periodically, have hydrophytes and the substrate is predominantly undrained hydric soil. They include the swamps, bogs, marshes and fens. Wetlands are also defined as areas where during a large part of the year water stands at 2.5 cm to around 300 cm.

According to the Asian Wetland Bureau, wetlands are "estuaries and deltas, salt marshes, mangroves and mudflats, coastal lagoons, fresh water lakes and marshes, salt marshes, flood plain wetlands, swamp forests, rivers and streams, man-managed systems such as rice fields, fish ponds and reservoirs".

Wetlands are of great help in controlling flood, in recharging aquifier, in the treatment of waste water, in growing finfish and shellfish and also as a source of water supply. They serve as reservoirs of rich biodiversity. But unfortunately wetlands are threatened as a result of increasing urbanization and other developmental activities.

3.2.5. Mangroves : forests between land and sea

Mangroves are unique forest communities in tidal zones of equatorial and tropical coasts. Chapman in 1977 used the term "mangal" for such communities and reserved "mangrove" for the specialized trees inhabiting this saline ecosystem. Such trees which are permanently affected by salinity during their whole life cycle have to cope with extreme conditions. This characteristic halophytic vegetation is found in saline and semisaline coastal areas in many places of the world. The Gangetic estuarine delta touching the Bay of Bengal—the Sundarbans is a typical example. It is also found in western India near the sea coasts of Bombay and Kerala, and in south India in the banks and creeks of Godavari, where the river meets the sea. The mangrove forests are also highly developed in the Andaman and Nicobar Islands. The predominant genera, which belong to different families, are ***Avicennia, Bruguiera, Ceriops, Rhizophora, Aegiceros, Aegialitis, Laguncularia, Lumnitzera, Kandelia*** and ***Xylocarpus***.

The characteristic adaptive features of the mangroves are described here.

(i) Several species of ***Sonneratia*** and ***Avicennia*** develop breathing roots, the pneumatophores, to improve their oxygen supply in muddy, regularly inundated substrates (figure 3.1).

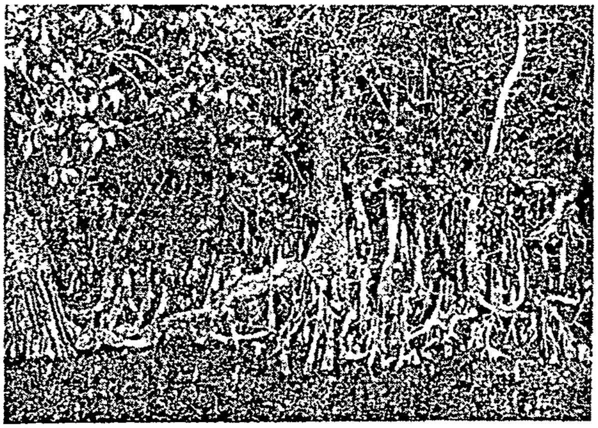


Fig 3.1 Breathing roots (pneumatophores) in a mangrove forest of the Sundarbans.
(Courtsey : Dr Kumud Sankar Naskar)

(ii) Some mangrove trees like ***Rhizophora, Avicennia*** and ***Kandelia*** have peculiarly shaped fruits with viviparous seeds, which germinate inside the fruit while still attached to the mother plant. In this way, the seedling stage is shortened and they can rapidly occupy their habitat.

(iii) Another adaptation is the formation of stilt roots arising from the main trunk of the trees for efficient anchorage in the loose soil.

3.3. Environment, flora and fauna : interrelations and interactions

Environment has been defined as the sum total of all conditions that affect the development and life of organisms. Every living organism, from the lowest to the highest, including human beings, has its own environment. Indian and southeast Asian region is rich in flora and is considered to be the centre of origin of many cultivated plants. This region is particularly suitable for rice, millets, soybean, cowpea and other important legumes, cucumber, egg plant, tropical fruits like banana, citrus, mango, plantation crops like pepper, betelnut, arecanut, sagopalm, coconut, cardamom, nutmeg, tea, cotton, jute and a number of tuberous crops like ***Dioscorea, Alocasia, Colocasia, Amorphophalus,*** ornamentals like orchids, rhododendron, jasminum, and the introduced rubber and oil-yielding plants like ***Hevea*** and oil palm.

The region is equally rich in fauna. Thousands of species of insects, crustaceans, molluscs, other invertebrates, fishes, amphibians, reptiles, birds and mammals are found. There is also a great diversity in domesticated animals like cattle, sheep, goat etc. Equally important are the microorganisms like fungi and bacteria which are very important component of the biosphere since they are responsible for the degradation of dead biomass and release of nutrients which are assimilated by plants and subsequently by animals.

Almost all the phases of environment have potential influence on organisms, but all factors are not equally important at any one time. Each single factor becomes more limiting in effect either in greater intensity when the organism will not be able to tolerate or in lower intensity when the organism may not be able to survive. For example, each plant has a maximum and minimum temperature tolerance and between these extremes lies a range which is the optimum range for this factor. Generally, the combination of factor intensities most favourable to the benefit of a plant differs at different stages of the life cycle. For example, the seeds of certain trees growing in marshy places prefer water content for maximum germination that is far above the requirement of the best growth of the mature trees. Another common experience in ecology is that one factor compensates for deficiencies in another. A high water table or an abundance of fog or low temperature, each may compensate for low rainfall. Again, there is good evidence that the effect of every nutrient element in the soil depends to some extent on the quantity of other elements present at the same time. So the wide range of environment tolerated by many plants may be partly due to the fact that deficiencies in one factor may be compensated for by others.

The occurrence and abundance of fauna are also regulated by environmental factors such as temperature, humidity, pH, salinity, BOD, food substances and many other factors. Organisms respond to the changes in their environment in four principal ways : (i) structural adaptations, (ii) physiological adjustments, (iii) behaviour patterns, and (iv) community relations. Population of two species may interact in various ways of which, competition, predation, parasitism, mutualism and commensalism are basic types of interactions.

3.4. Forest ecology

Forest ecology is defined as the study of a forest in reciprocal relationship with its environment. Since forests are to meet both physical and economic needs of the population, forest ecology combines in itself the study of all those factors that affect both natural and economic importance of forests. Forest management, a relatively new concept in plant ecology, has become an important ecofriendly practice in forest ecology. Thus forest ecology may be considered as a branch of applied plant ecology.

3.4.1. Importance of forests

Forests are among the most important biotic resources and forestry is gaining in importance as an integral part of National Development Program of countries throughout the world. The forest covers of the world carry great value for mankind ensuring economic development of the country, preserving environmental quality, providing employment to the weaker sections and meeting the basic needs of the rural population. Forests not only provide wood, fibre, fuel and shelter, but these have immense importance in the protection of the soil and maintenance of the climatic and environmental stability.

3.4.2. Management of forests

Indiscriminate felling of trees as a result of urbanization, industrialization, mining operations and the use of fire-wood and fuelwood for domestic and other purposes is causing a great depletion of forests. According to official statistics relased by the Forest Department, India has lost between 1952 and 1972 about 3.4 million hectares of forest lands to pave way for dams, new crop lands, roads and industries, which means an annual rate of removal of good forest cover of about 0.15 million hectares. If the present state of depletion is allowed to continue unabated, the country will be heading towards the situation of zero forest in about 20 years.

The most important object of forest management is to maintain and to improve site quality, specially when the soil is liable to erosion. Besides this, forests are to be managed in such a way that periodical removal of forest produce would not endanger future yields. Sound forest management should ensure an adequate regeneration of trees. Regeneration may be by seeds or coppice. In the coppice system, timber is cut leaving about one metre of the tree from the base which regenerates into new shoots.

Silviculture is the term for forest management which deals with the planting and production of timber trees. For the management of forests under silviculture system, the knowledge of climatic conditions, drainage pattern, ecological life cycle of important plant species and their biotic interrelationship is necessary.

Conservation of forests : Management practices should also include the protection and conservation of forests. In India, an organized movement to save trees was started in 1972 which has now become famous as Chipko Movement. This movement has brought a country-wide general awareness about the importance of conserving forests and the trees. The integrity and proper function of forest ecosystems are intimately associated with the health and prosperity of living beings. Tree planting can be done in private individual lands, vacant land on the banks of ponds, embankments and along the railway tracks. The aim of the forestry program will be two-fold : (i) creation of green belts for changing landscape in a planned manner, and (ii) planting of such trees which will increase the economic resources and help in the livelihood of the people.

3.5 Problems of sustainability of stable ecosystems

Under normal condition, each ecosystem tends to remain stable. But if there is any kind of qualitative and quantitative change in the components comprising the ecosystem, the sustainability of the system gets disturbed. It means that the power of self-maintenance and self-regulation of the ecosystem is jeopardized which may adversely affect environmental health. This ultimately causes human misery. In order to maintain the sustainability of the ecosystem, there should be least intervention in the working of the ecosystem. But mankind without understanding and appreciating the subtle links among the components of the ecosystem very often disrupts a natural ecosystem at times irrevocably damaging its stable structure and functional efficiency.

CHAPTER IV

POPULATION AND ENVIRONMENT

4.1. Carrying capacity : limits to population growth

Humans are relatively new arrivals at the planet earth. They have no special immunity. With other biological species they share the threat of extinction. It is apprehended that within several generations the survival of human species may be at stake because of the disruption of earth's life-supporting ecosystems. An ecosystem is defined as the web of inter-dependence, of mutuality, between living organisms and their physical and biological environment.

We humans cannot live apart from nature. We cannot live remote from the great web of life. But risks to human population health are arising from the disruption of natural systems because we are exceeding the biosphere's carrying capacity i.e. the planet's intrinsic capacity to absorb, replenish and restore. Most aspects of this planetary overload are the product of human activity in recent decades : increased emission of greenhouse gases, damage to stratospheric ozone layer, depletion of aquifers and destruction of rainforest. They impair the productivity (of soil, forest, ocean, biodiversity) or stability (of climate, sea level, ultraviolet filtration) of earth's natural systems. Carrying capacity of the environment is a useful, though not a very rigorous concept. It refers to the capability of a given system to support a population. For example, if the prevailing agricultural system produces X calories and that each person needs a minimum of Y calories to survive, then the carrying capacity of the system (computed as the number of persons that can be sustained per square kilometre of land) is equal to X divided by Y (i.e. X/Y).

The carrying capacity of an area is not the desirable level of population as carrying capacity is usually defined as the maximum sustainable population at the minimum standard of living necessary for survival. Maintaining the maximum number of people at a minimum standard of living, hardly qualifies as a desirable objective.

The Food and Agricultural Organization (FAO) of the United Nations carried out an extensive analysis of the carrying capacity of the world. The potential food production of each of the 117 countries was considered. As potential food production depends upon the technology used in agriculture and as technologies may be of different levels, FAO considered three levels as shown below.

(a) **Low level** : technology without use of fertilizers, pesticides or herbicides, as applied in the production of traditional crops, and without any consideration of long-term conservation measures;

(b) **Intermediate level** : technology using basic fertilizers and biocides, use of some improved crop varieties and some basic conservation measures;

(c) **High level** : technology fully using fertilizers and biocides, using improved crop varieties, conservation measures and the best crop mixes.

Potential calories output was then estimated on the basis of these different technological scenarios. By dividing this potential calorie output by the per capita calorie intake recommended by FAO and WHO for each country, a sustainable population was estimated, for each of the years 1975 and 2000.

The table below sets out the result in a convenient form. With reference to the year 2000, it shows the ratio of potential sustainable population to the expected population for various regions of the world, and at the three different levels of technology.

Table 4.1.. Carrying capacity (number of people/sq km) of different regions of the world at three thechnology levels

Technology level	*Africa*	*South West Asia*	*South America*	*Central America*	*South East Asia*	*Average*
Low	1.6	0.7	3.5	1.4	1.3	1.6
Intermediate	5.8	0.9	13.3	2.6	2.3	4.2
High	16.5	1.2	31.5	6.0	3.3	9.3

The table shows that barring South West Asia, even at the lowest level of technology, all other regions could support more population than the number of people expected in the year 2000. At a high level of technology, for the developing world as a whole, its lands could support 9.3 times the number of people expected in 2000. Thus as technological level improves, carrying capacity of the regions improves remarkably. The data presented in the table might appear to suggest a fairly optimistic picture. It certainly highlights the role which technological improvement can play in vastly upgrading carrying capacity. However, it is important to understand why the picture is not as optimistic as it appears to be.

It must first be noted that carrying capacity refers to the maximum number of people that can be sustained with the given resource, and not to the desirable number of people. Second, carrying capacity relates to a minimum calorie intake and, thus, such an approach makes no allowance for increasing nutritional levels. Third, the time horizon of 2000 is too limited to permit much change to take place in levels of applied technology so that the high technology level scenario is of little relevance to what will actually be the case. Fourth, the approach assumes that all cultivable land will be under food production alone, which is clearly an exaggeration of what is feasible.

The situation may in fact be worse still. The FAO study was concerned with carrying capacity in terms of food only. There is no consideration of other resource scarcities, which may exert an influence before the land limit is hit.

For example, no account is taken of the availability of fuelwood. A study of the Sahelian and Sudanian zones of West Africa estimated the carrying capacity of various zones according to the limits set by crops, livestock and fuelwood. The results are shown in the table given hereafter (Table 4.2).

Table 4.2. Carrying capacities in Sahelian/Sudanian zones of West Africa (in people/km^2)

Zone	*Sustainable Population*			*Actual rural population*	*Sustainable population : fuel wood*	*Actual total population*
	Crops	*Livestock*	*Sum*			
Saharan	—	0.3	0.3	0.3	—	0.3
Sahelo-Saharan	—	0.3	0.3	2	—	2
Sahelian	5	2	7	7	1	7
Sahelo-Sudanian	10	5	15	20	10	23
Sudanian	15	7	22	17	20	21
Sudano-Guinean	25	10	35	9	20	10

It will be observed that carrying capaity of fuel wood is lower than that of crops using traditional technologies. Moreover, in three of the regions fuel wood carrying capacity is already exceeded, compared to three regions where food and livestock carrying capacity is exceeded. The general picture on world zone carrying capacities may therefore understate the problem of resource carrying capacity generally. What matters is which scarcity pinches first.

4.1.2. Human population distribution in the world (population dynamics with special reference to developing countries)

It is of the utmost importance to understand that starting from around 1700 until well into this century, the population of Europe and North America (most of the modern developed world) grew not only in absolute terms, but also relative to the peoples of those regions we know today as the developing world. To see this shift in population, it is useful to take a long-term view. Table 4.3 is taken from a revised estimate of the world population over the last few centuries. We append to this table the 1995 estimates from the United Nations Demographic Year Book. The results are very interesting.

Table 4.3. Geographical distribution of the world population in different continents

	1650	1750	1800	1850	1900	1933	1995
World Population (millions)	545	728	906	1,171	1,608	2,057	5,716
Percentage distribution							
Europe	18.3	19.2	20.7	22.7	24.9	25.2	12.7
North America	0.2	0.1	0.7	2.3	5.1	6.7	5.1
Oceania	0.4	0.3	0.2	0.2	0.4	0.5	0.5
Latin America	2.2	1.5	2.1	2.8	3.9	6.1	8.4
Africa	18.3	13.1	9.9	8.1	7.4	7.0	12.8
Asia	60.6	65.8	66.4	63.9	58.3	54.5	60.5

Source : Carr-Saunders, A.M. World Population : Past Growth and Present Trends (1936), and Demographic Year Book (United Nations, 1995)

The table is constructed to highlight the earlier centuries. If we neglect the last column for the present we have an array of population percentages all the way from 1650 to 1933. We observe the decline of Africa, in significant part due to out-migration, and the rise of North America, in large part due to immigration. On the other hand, despite out-migration from Europe, her share of the world's population rose steadily over the period. Focusing on the data in the first column and the sixth column would clearly reveal how the situation altered over the period 1650-1933. What we see here is the period when Europe began its demographic transition, while large parts of the present developing world still lay dormant in the first phase of demographic history. In 1650, the population of Europe was about 100 million. In 1933, even allowing for emigration which was large, it had swelled to over 500 million.

Looking at the last column of Table 4.3, which pertains to 1995 it appears that we are in the throes of a reverse swing. Asia, which lost around six percentage points over the period 1650-1933, has returned to almost exactly the 1650 share. Africa has come back as well, but is still significantly below the 1650 share. The two gainers have been North America and Latin America. It is also instructive to add up what approximately accounts for the developing world. The population share of Asia, Africa and Latin America combined was 81.1 percent of the world population in 1650. In 1933 it had dropped to 67.6. The share was 81.7 percent in 1995. We have come full circle.

What bothers many governments in the developed world is not population growth, but relative population growth. A large population means greater poverty and smaller per capita access to resources but on the international scene, it stands for greater political and economic power. As such, the very same governments of the developed countries that stand for population control in the developing world are perfectly capable of pursuing pronatalist policies at home.

At the same time, we cannot help being concerned about future trends. It took Europe and America a good 283 years to realize the population gains, it took around 62 years to lose them. If these trends are extrapolated, we are in real danger of an enormous population explosion, with a rising majority in the developing countries.

In facing this phenomenon, we must take note of a radical difference between the demographic transitions of the developed and developing world. Demographic transition in the developing world is taking place at a pace many times faster than that of the developed world. This second phase of demographic history in developing countries displays an intensity that is unmatched by the experiences of the now-developed world.

In developed countries, the fall in the death rate was relatively gradual, limited by the trial and error of innovation. By contrast, in the developing countries the decline of mortality was widespread and sudden. In the developed countries, the improved production of food, the institution of sanitation method and the greater control over disease yielded by medical advances all had to be discovered or invented, rather than transplanted from a pre-existing stock of knowledge. By contrast, in the developing world antibiotics were available for a variety of illness, they did not have to be reinvented : the use of insecticides such as DDT provided a cheap way to bring down malaria to manageable proportions. There was widespread application of elementary method of sanitation and hygiene. The fact is that the easy and universal application of these new techniques led to a precipitous decline in death rates. The speed of decline surpassed anything experienced by Northern and Western Europeans. Everything, then, hangs on the birth rate. How quickly does it follow the death rate on its downward course ? On this question hangs the future of the world's population.

4.2.1. Population growth and natural resources

In the final decade of the twentieth century, world population size has been estimated to be approaching an annual increase of 100 million per year. This is a record-breaking rate of increase and this cannot go on for long without disaster. We are living through a demographic aberration. During the nineteenth century the annual increase was around 10 million. Over the preceding five centuries it was around 1 million per year. Today, we have a massive upsurge in global population and it is apprehended that this will have adverse environmental impacts. Some impacts result largely from population overload. This is exemplified by the consequences of prodigious coal-burning, increased rice-field methane emissions and widespread deforestation. Others result primarily from poverty — for example, poor sanitation, use of marginal farmlands, soil degradation from intensive cropping, excessive logging and burning of forests and uncontrolled industrial pollution.

In their book, The *Population Explosion*, P.R. Ehrlich and A. Ehrlich have summarized the determinants of environmental degradation algebraically in the following manner : the aggregate environmental impact (I) of humans is the product of the number of people (P) times their level of affluence (A) times the type of technology and waste disposal (T). That is : I=PxAxT. This basic formula is readily applicable to rich countries. So far as poor countries are concerned, the formula should be applied with caution since in those countries the meagre A (affluence) causes environmentally destructive forms of T (waste disposal). For example, desperately poor farmers in Ethiopia clear and plough the stoney hillside land, and most of the soil is soon washed away. China, striving to raise the affluence (A) of more than a billion people, intends to double its combustion of coal very soon. In the formula there looms a recurring multiplier, the burgeoning human population (P), that strains the biosphere's carrying capacity. Demographers tell us that even if the world's birth rate were immediately reduced to replacement level, the demographic momentum of the oncoming pre-adult population would still cause a 60% increase in world's population from 5.5 billion to 9 billion, by around the year 2030.

As population increases, there will inevitably be a stepping-up of economic activity. Such activity can be viewed as a process of transforming materials and energy a large part of which will appear as waste that eventually, will be discharged to the environment. This suggests that the bigger the economy gets, the more waste will be produced. If we think of stocks of waste. Second, the relation was derived on the basis of cross-section data. Hence it does not imply that for a given poor country the environment will automatically improve with income over time. Third, there are certain irreversibilities in environmental damage. The earth's resource base may not be able to recover if countries such as China or India now deplete or pollute at the same rate as countries like the United States did at the early stages of industrialization and are still continuing.

The most pressing environmental problems are associated with resources that are regenerative but are undervalued and are therefore in danger of exhaustion. Air and water are renewable resources, but they have a finite capacity to assimilate emissions and wastes. If pollution exceeds this capacity, ecosystems can deteriorate rapidly. When fisheries or forests are excessively depleted to meet human needs, critical thresholds may be passed, resulting in the loss of ecosystems and species. Shortages of nonrenewable resources, such as metals, minerals and energy are of less concern. The evidence suggests that when the true value of such nonrenewable resources is reflected in the market place, there is no sign of excessive scarcity.

The points regarding concern about regenerative and nonrenewable resources need elaboration. Water provides an example of an undervalued renewable resource that is showing signs of shortage. Six East African countries and all the North African countries have annual renewable water supplies below the level at which societies generally experience water shortages. In China fifty cities face acute water shortages as groundwater levels drop 1 to 2 meters a year. In Mexico City groundwater is being pumped at rates 40 percent faster than natural recharge. In many countries scarce water is used for low-value agricultural crops, and farmers pay nothing for the water they use. The misuse of water in the Aral Sea in Central Asia is an extreme example to recognise the value of a natural resource.

For natural resources that are nonrenewable, increases in consumption necessarily imply a reduction in the available stock. There is no evidence, however, that marketed nonrenewable resources such as metals, minerals and energy are becoming scarcer in an economic sense. This is because potential or actual shortages are reflected in rising market prices, which in turn have induced new discoveries, improvements in efficiency, possibilities for substitution, and technological innovations. The rise in the prices of metals and energy in the 1970s encouraged efficiency gains and substitutions that ultimately reduced the growth of demand. Examples of such technological changes include fibre optics which replaced copper in telecommunications, the use of thinner coatings of tin, nickel, and zinc in a number of industries, the development of synthetic substitutes such as plastics and related polymers and the recycling of aluminium and other materials. Similar efficiency gains were achieved in the energy sector. The use of metals and of energy per unit of output has declined steadily in industrial countries. Current consumption as a proportion of reserves has declined for several mineral and energy resources. Declining price trends also indicate that many nonrenewables have become more, rather than, less abundant.

The world is not running out of marketed nonrenewable energy and raw materials, but the unmarketed side effects associated with their extraction and consumption have become serious concerns. In the case of fossil fuels, the real issue is not a potential shortage but the environmental effects associated with their use, particularly local air pollution and carbon dioxide emissions. Similarly, the problems with minerals extraction are pollution and destruction of natural habitat. Because 95 percent of the total material removed from the earth is waste that often contain heavy metals such as mercury, lead etc. which commonly find their way into rivers, groundwater, and soils.

4.3.1. Impact of economic development on environment in India in particular

Until a century ago, India's natural rsources — cultivable lands, forests, grazing lands and minerals, not to mention clean air and clean water — were far more abundant than they presently are. Population was but a quarter of what it is today and per capita income was about half its current level. The accessibility of some of this abundance permitted the bulk of the population to meet its basic requirements of fuel and housing materials, as also of fodder, animal dung and artisanal materials by expending labour alone. A sizeable part of the population met even its food needs by an assortment of activities including fishing, gathering, hunting, cattle grazing and shifting cultivation.

From 1865 onward, the colonial regime enacted a series of laws converting a great deal of common lands, all water sources and much of the forested area into state porperty. This served to raise the revenues that financed the empire and fuelled the ongoing industrialization of Britain with raw materials. However, state property and monopoly also provided a convenient cover for private and privileged appropriation. Planned development was initiated in 1951 with massive investments in infrastructure. As a result both GDP (Gross Domestic Product) and per capita GDP grew several times over the ensuing period. This entailed an enormous extension and intensification of natural resource extraction, resource degradation and pollution.

4.3.1.1. Land

Two-thirds of the work force continue to derive their livelihood and many of their basic requirements from the primary sector. The slow growth of non-agricultural employment has not relieved population pressure on the land. The land frontier itself has long since run out. As a result, vast areas of semi-arid and fragile soils have been brought under the plough and close to 60 percent of agricutural land is degraded to varying degrees.

Quite apart from the natural action of water and wind, land degradation is the result of intense biotic pressure on forests, waterlogging and salinization traceable to deforestation and imporper management of irrigation, and soil erosion caused by inadequate investment in soil and water conservation activities. At 16.35 tonnes per hectare a year, India has an alarmingly high rate of soil erosion. Satellite imagery showed only 64 million hectares (19.5 percent of total area) to be under forest cover during 1987-89 compared to a government target of 33 percent, of this only 7.36 million hectares are forests with adequate crown cover.

According to the National Commission for Agriculture, some 6 million hectares of agricultural land suffer from waterlogging and another 7 million hectares from soil salinity and alkalinity. These account for a quarter of irrigated lands (or one-eleventh of cultivated lands). Areas prone to floods are estimated to be 18 percent of the total and to have grown at over 4 percent per annum since the late 1960s, perhaps reflecting the combined effects of land extension, intensification and deforestation.

Despite rising water and input intensity, land-use patterns and techniques account for the very low agricultural yields. Similarly, two-thirds of land classified as non-agricultural consists of denuded forests and land with very low useful yield. Indian forests suffer generally from low productivity levels that are only a third of the world average. The growing pressure on land and forest resources described above produces increasing burdens on rural people, particularly the poor. This may be ligitimately described as a subsistence crisis, an important manifestation of which is the rapid decline in common property resources (CPRs), including grazing and forest lands and water courses. CPRs are specially important in supporting subsistence farming via the sustenance provided to farm animals. Yet, over the past four decades CPR area declined between 30 percent and 50 percent even as their yields were strained by the doubling of population.

4.3.1.2. Water

It is alarming to note that the average annual availability of water per capita has declined from 5,236 cubic metres in 1951 to only 2,227 cubic metres in 1991. It is apprehended that with population increasing, this will decline further to only 1,555 cubic metres by the year 2,013. Even if this level of water supply should prove sufficient in the aggregate, the enormous regional variations in water availability will pose serious problems of water distribution and aggravate the already prevalent socio-political conflict. Despite much faster expected growth in water demand for energy and industry through the year 2025 compared to irrigation, the latter will still account for 73 percent of water use compared to 83 percent presently. According to one study, given current water-use practices, water will be the effective constraint, not land. The calculated water deficit, depending on various yield scenarios, ranges from 21 percent to 63 percent.

4.3.1.3. Habitat

The system of production also affects the living environment or habitat of people directly— the water they drink, the air they breathe and the physical amenities (i.e. cooking fuel, housing, sanitation, energy and transport forms) they use to live and work. There are consequent effects on people's health and survival chances, which then feed back on the production system. These effects may be expected to be particularly severe given the widespread poverty in India and the low level of fulfilment of such basic needs as food, water, sanitation, health services and housing. The low rate of literacy also implies that many people are unaware of the ways in which environmental conditions affect their lives and of the social means by which they might seek redress.

Over two-thirds of all drinking water is obtained from surface sources such as rivers, lakes, ponds and open wells. About 80 percent of the population does not have access to safe drinking water. According to YCP (Yashvantrao Chavan Pratisthan, Bombay), some 1,75,000 villages still are without potable water. The urban poor too suffer from a particular lack of access to drinking water with only a third or so having safe access. In consequence, the poor must take resort to polluted surface sources. Over a quarter of water remains unaccounted for in many towns. Water tariffs well below cost mean that conservation and recycling incentives are weak.

Apart from availability itself, overexploitation of groundwater and pollution of surface sources are the key problems. According to YCP, seventy percent of surface water is seriously polluted primarily because industrial affluents and sewage water remain largely untreated before being discharged into waterways. The rising share of industrial water demands in urban areas does not protend well for water sources. In rural areas, the growth of groundwater irrigation is posing an increasing threat to them.

Over a third of India's urban population live in slums. Land values are extraordinarily high and living conditions accordingly worse in million-plus cities whose number has grown from just one in 1901 to 23 in 1991. Even as housing for the poor is squeezed by rising land values, congestion and transport difficulties increase apace. About three-quarters of urban households are without adequate sanitation. Only 15 percent of them have private toilets and 60 percent resort to open defaecation. Less than half of waste water is collected of which less than half is treated at all. Water and sanitation related illnesses such as cholera, dysentery and gastroenteritis accounted for about 60 percent of all urban deaths.

4.3.1.4. Air

Air pollution in the bigger cities is a growing hazard to health and comfort. Increasing rates of respiratory illness, specially among children, have been recorded for cities such as Delhi. In the four metropolitan cities, suspended particulate matter (SPM) is 360 mg/cum compared to WHO standard of 150. Apart from SPM, the pollution load due to industrial emissions and vehicular exhaust is also growing. Although effluent standards for 23 industries and emission standards for 21 industries have been set as part of the minimum national standards (MINAS) programme, enforcement has proved difficult and dilatory and relocation of non-compliant firms often impossible. Due to their more dated technologies, the existence of scale economies in pollution control and the greater difficulty of regulatory monitoring and enforcement, small firms probably generate more pollution per unit of output than do large firms.

For the vast majority of our countrymen, particularly the poor, indoor air pollution due to smoke and fumes from the burning of biomass (wood, agricultural residues and dung) chiefly for cooking is the principal hazard. Women and children are most exposed to it. What is more, women and children in rural areas are compelled to spend many hours in collecting biomass which provides 87 percent of all cooking fuels. The growing shortage of biomass is raising the effective cost of using it but still it is cheaper than the alternatives. Although biomass fuels provide 34 percent of primary energy and 70-90 percent of household energy, these are low efficiency fuels. The poor cannot afford the initial investment costs of liquified petroleum (LP) gas and other alternatives. As a result, the effective energy cost to the poor can be twice as high as that for the rich.

CHAPTER V

LAND AND WATER RESOURCES OF THE EARTH

Land, water and air constitute the abiotic environment in general. Land belongs to the lithosphere, water to the hydrosphere and the air to the atmosphere. The biosphere or the domain of living organisms on earth's surface encompasses all the three spheres except that the atmosphere does not provide permanent residence to any organism. The habitat of any species is controlled by the characteristics of land, water and air. We find the living species either on land or water. So there are distinct ecosystems like (i) ***terrestrial ecosystem*** and (ii) ***aquatic ecosystem***. In between the land and water we also find a ***transitional ecosystem***, known as (iii) ***wetland ecosystem***. Atmosphere is constituted of different gases like nitrogen, oxygen, carbon dioxide, argon, water vapour and many others, which control the climatic conditions on earth's surface and is sometimes called the ***climatic environment***. Different biomes in the terrestrial ecosystem like ***Tundra, Savanna, Rainforest, Deserts*** etc. are mostly governed by the climatic environment.

5.1. Land resource of the earth

Land constitutes less than one third of the earth's surface (nearly 29%). But land's environment is crucial for human beings, as they live on land. Their sustenance depends on quality of the land. Most of the human occupations — say agriculture, mining, industry etc. are land specific. Even in the primitive society man depended solely on land resources in food gathering and hunting. With the progress of civilization and innovations of technologies man has affected the land — many forests have been cleared, many species have become extinct and much of the resources greatly depleted. Degradation of lands has become a crucial issue today in regard to sustenance of life on earth's surface.

Let us have a glimpse of the land situation in the world given in the table below.

Table 5.1. Pattern of land distribution (in billion hectares)

Total land	*Arable land*	*Permanent meadows and pastures*	*Forest and woodland*	*Other land (barren and non arable land)*
13 (100%)	1.44 (11%)	3.36 (26%)	3.89 (30%)	4.31 (33%)

Though it may appear that the percentage of cropland on a global scale is low, the percentage is very high (45%) in South Asia, moderate in U.K. (25%), U.S.A. (21%), Germany (35%), France (35%) and other developed countries, very low in Sub-Saharan Africa (7%) and Australia (6%).

Land may be defined as *space*, in that sense land is a fixed quantity that cannot be either created or destroyed. In one way the land is a renewable resource, but with a finite limit. Land can also be closely identified with nature and as such natural environment like insolation, rainfall etc. are intimately associated with the concept of land.

Land produces food, gives shelter — in that sense it serves the people with the supply of consumer goods from its source. This concept of land is similar to that of a land as consumptive goods. Here lies the diabolical character of the land. We have been considering land more as consumptive goods, than as a part of the natural systems. The natural systems are thus affected adversely through overexploitation to satisfy our greed.

5.1.1.Land areas

The total land area in the world has been estimated at about 148,429000 sq km. Of this land area Asia covers nearly 30 percent (44,579,000 sq km) — the highest in the world. Next comes Africa with land area amounting to 30,065,000 sq km and 20 percent of the total land area in the world. North America, South America, Antarctica and Europe occupy 16.3, 8.9, 8.9 and 6.7 percent land areas of the world. Australia holds the least landmass in the world having 7,687,000 sq km area and 5.7 percent of the total land surface of the world.

5.1.2. Topography

A land may be characterized as mountain, plateau, eroded plain, deserts, glaciated highland, lowland etc. All such characteristics of land are expressed in terms of topography. The topographical forms indicate a particular type of environment, where a specific type of habitat develops. We find in general that harsh mountain environment inhibits the growth of species due to very cold condition and steep slope. But in tropical lowlands life flourishes favoured by warm temperature, good rainfall and flat terrain. Compared to this, life in desert is also restricted due to paucity of water and scarce rainfall. From a cursory look at the atlas we find that the plateaus cover dominantly all the continents. The continents in the past were formed out of volcanic rocks, which being eroded had formed the plateaus. Barring the Saharan desert most of Africa is physiographically a plateau or table land. The plains have been formed along the narrow coastal belts, where dense population is found. The core of the equatorial Africa is covered with tropical rainforest, but strewn with isolated patches of settlements. The widespread rain forest can also be observed over the Brazilian plateau in the Amazon basin. These rainforests are of prime significance as they form the sink of carbon dioxide on earth's surface and renew the atmosphere with the release of oxygen. Temperate plateau areas in Eurasia continent experience the harsh cold climate in winter and relatively dry summer, thus inhibiting the growth of vegetation and other species. Population density is also remarkably low. The mountain chains in Central Asia form highlands where living conditions are not favourable. But the riverine plains in south and southeast Asia record very high growth of population and settlement. Similarly the east-central part of North America has extensive lowland formed due to glacial till and glacial depositions. But the western part is characterized by high plateaus and young fold mountain chain. Though the central part of Australia is nearly levelled plateau, aridity has caused very low population growth. Antarctica is a part of the Gondwana continent and a plateau region where extreme cold conditions are manifested by temperature below freezing point throughout the year. So it has been turned into a cold desert, where living species are few.

5.1.3. Soils

Soils that form the veneer of the land surface is very important for biotic generation. Soils can hold water and help in the growth of plants, many microorganisms etc. Most plants get their nutrients from the soils for their sustenance. So soils are considered very important environmentally. Soils are formed due to weathering of rocks from the regolith and due to the interaction of climate, vegetation, topography etc. on it in the later stages. In soil we find three distinct horizons namely, A, B, and C. The horizon A is the layer of leaching, B is the layer of deposition and C is the parent rock. The amount of leaching and deposition in a typical climatic and vegetative environment decide the characteristics of the soil including the fertility status. Broadly we find two groups — namely ***pedalfers*** and ***pedocals*** that are respectively the soils of humid and semi-arid regions. Pedalfers are ***light textured*** in A horizon, but ***heavy*** in the B horizon with deposition of ferruginous (iron containing) materials including the ***clay-humus complex.*** Pedocals are less leached in A horizon and are rich in mineral nutrients and bases, particularly calcium carbonate. ***Pedsol*** is the best example of pedalfers and ***chernozem*** or black soil belongs to pedocals. Laterites develop under tropical climate having alternating dry and wet seasons. Alluvial soils are transported soils, borne by different agents of erosion like rivers, winds, marine waves and glaciers. Where such deposits are accumulated they form layers to develop distinct horizons. The fertility status of the soils is a key to productive agriculture and so the quality of the land is expressed in terms of fertility status of soils. But soils are also subject to degradation due to over-exploitation and unwise cultivation. Each year billions of tons of top soil are eroded and removed causing deep concern for sustainable agriculture.

5.1.4. Quality of land

The quality of the land is one of the most important aspects of the environment. With the explosion of population in the last few decades the impact upon the land had been adverse. As mentioned the land is a fixed asset, the tremendous pressure of population had resulted in the expansion of farm lands at the expense of the marginal lands. It can be seen that although about 11 percent of the land surface is now cultivated, there is little additional land that can be further converted to cropland and cultivated sustainably. Moreover it can be seen that in Bangladesh and India the croplands occupy 67 and 57 percent respectively of the total land surface. Further expansion of the farmlands seems to be impossible. The alternative to feed the rising population with increased production of crops is only possible through enhanced productivity by technological innovations.

5.1.5. Land degradation

Productive lands for sustainable agriculture have been subject to deterioration day by day due to over exploitation. ***Human Development Report***, 1998 states that since 1945 nearly 2 billion hectares of productive land have been degraded. This amounts to about one-sixth of the world's productive land. The carrying capacity of the land has thus been reduced substantially. Interestingly the loss of good cultivated lands has been spectacular in the developing countries. Nearly half of the world's degraded lands belongs to Asia and nearly one-fourth of the moderate to strongly degraded land lie in Africa. These parts of the globe require more food to feed ever increasing hungry people, where acute food shortages and famines are recurrent. Here live two-thirds of the world's poorest people. Hence land degradation has become a menace of great concern to the world community.

5.2. Landuse

Land is fixed and inexhaustible — it cannot be either expanded or lost, if properly managed. Land is subject to various uses to cater to the growing needs of the society. It can be found that many societies which flourished in the past suffered badly with the degradation of land resources. The degradation was principally the result of misuse. Hence wise use of land is essential for the development of any country. Landuse planning must consider the following facts.

i) In the first place land can be described as the nation's ultimate asset and it is to all intents and purposes fixed in area and inextensible. It is true that small areas may be added to it by land reclamation of such small tracts as tidal marshes. But in recent years it has been observed that even such reclamation has not become beneficial in the long run. If the lands are not properly managed the loss of land results due to soil erosion.

ii) Secondly, land is part of nature. The overall physical terrain of land cannot be easily or conveniently moderated. The slope of the land cannot be greatly altered by human efforts. In one sense the characteristics of the land seem to be permanent and unalterable. The high areas will remain uplands and the low areas lowlands. Land broken by numerous slopes will continue to be of same characteristics. Any efforts of levelling over a wide region will certainly fail, but many barriers to communication may be overcome by tunnels, cuttings and gradation of roads. Even such efforts are themselves dictated by the physical conditions of the land. A large terrain of land cannot be easily transformed into a first class farm land by human efforts only. The physical characteristics of land will certainly dictate the terms for conversion into first class farm lands. Most lands can be upgraded only to a certain level depending upon the starting point, which is the inherent character of the land. It is also very important to understand that such upgrading can be, and usually is, an expensive process. We must therefore recognize the continuing influence of physical form of land on its utilization.

Still less alterable is its geological structure and the dispositions of minerals of economic importance. To a considerable extent the climatic factors also appear to be permanent and unalterable. Whilst it is easy to make up deficiencies of rainfall by irrigation, it is much more difficult to deal with excess of precipitation and heavier rainfall areas remain problem areas. Provided the value of the produce justifies the expenditure, glass-house or green-house cultivation can overcome the disadvantages arising out of temperature conditions for crop growth particularly in middle and high latitude regions. The type of crop farming in general is dependent upon climatic conditions. Micro-climatological studies are needed for special type of landuse such as orchards, nurseries and market gardens.

Land planning is in essence the determination of optimum use of every hectare of land of the country. Clearly optimum use is not the same in time of war as in time of peace, and optimum use must necessarily change from decade to decade with prevailing economic conditions. Any landuse planning must accordingly be dynamic and not static, flexible not rigid, capable of being adopted by changing conditions, not forgetting changing habits of the people. But the criterion must not be as it has often been in the past namely, the economic advantage of some favoured section of the community. The criterion must be decided by the national advantage. The land as a whole must be used to satisfy as many needs and legitimate desire of the people as possible keeping in view the interest of the nation as a whole.

Closely connected with the principle of optimum use is the principle of multiple use. In a way, the whole country side is a national asset, to be used for the benefit, including enjoyment of all people. The highlands of the country should be so planned as to serve the needs of forestry and of hill sheep farming and to serve at the same time as gathering grounds for water supply both for domestic and industrial uses.

The most essential need for mankind is food, which is produced by the farmer. The farmer, therefore, will have to maintain and improve the fertility status of the land, for which he would require the security of tenure. It is five or six years after certain agricultural projects are planned and implemented before the farmer sees a final return. Such planning is impossible where there is the danger of loss of land for other purposes. Thus good landuse planning should demarcate the areas within which non-agricultural development may take place on agricultural land.

The second basic need of the people is shelter — a hygienic and comfortable home. Housing therefore takes a very high priority in its demand for land especially in the face of a steadily increasing population. Even in the developed countries where the annual increase in population is at present low and the age composition of the people is such that the number of family units is still increasing, with the result that a large number of individual homes is required for the same number of people. To this position must be added the obsolescence of a large proportion of existing housing and the breaking up of joint families and consequent need for more houses. New houses are required in relation to the location of new industries or rehabilitation of old industries. As far as rural housing is concerned it is now widely recognised that further fragmentation of land holding and use of valuable agricultural land for building huts and cottages cannot be avoided.

The urgent need of the majority of people is work, and we must therefore, suggest that right location of the industry is essential. With industry, of course, should be linked commerce and all the attendant necessities of modern life. We should strive for a balanced location of industry, well distributed over the country in older and newer industrial areas, and it is important to make available land necessary for modern type of factory. In a given area the selection of sites is broadly a question of planning. Both for the factories themselves and for the attendant housing it is often possible to select sites which will avoid the use of better agricultural land and the breaking up of good economic agricultural units.

Fourthly, there is the vital use of the land for the essential lines of communication — by railways, roads and latterly by air — so that those resident in one area may enjoy the facilities provided in another, as well as for the all important free movement of goods. It should be impossible to enjoy the fruits of the most comprehensive and carefully worked out landuse planning without the feeling of security which the nation has a right to enjoy. Hence an essential use of land is for defence services — the Air Force, Army and Navy. Their demands upon land are likely to increase with the increase in size of modern weapons, but there is every reason to hope for a greater flexibility than in the past.

Another important need of the people is recreation. Unfortunately, it is an outdated mode of thinking that holidays and leisure are luxuries for the few rather than necessities for all. Parks and playing grounds in town planning schemes are now necessities, not luxuries. The same principle applies to recreation as the optimum use of many of the scenically beautiful or wild tracts of the country. This point of view was long recognized by those who advocated *National Parks* and became a part of government policy in 1945-46 with the official recognition of the need for National Park. But the principle of multiple use must never be forgotten. It is the access by road, bridle path and foot path to the ordinary country which matters even more than special demarcation of certain holiday areas. Whilst there is a deep seated desire of many for a small place in the country, there is often a conflict between this individual desire and the need to keep unspoiled an otherwise open country or beautiful stretch of sea coast from what has been called "an unpleasant bungaloid growth". The legitimate desire of the individual can be satisfied by the careful location as well as careful design of the country dwelling.

5.2.1. Factors governing landuse

Many factors influence the pattern of utilization of specific land classes. Broadly, three sets of factors, namely, (i) ***Physical,*** including site, topography, soil, climate etc., (ii) ***Economic,*** including monetary system, credit and capital, trade and commerce, transport and technology etc., and (iii) ***Institutional,*** including cultural environment, soical and collective action, customs and traditions, attitudes, value system and the legal system etc. would play significant role in changing the landuse pattern in a typical set up. As many attributes control landuse over a region, when such attributes vary, the changes are reflected in the use of lands. Let us understand such changes with specified landuse.

(i) Physical or natural : Natural or physical factors include attributes like soil characteristics, topography, climate etc. The soil characteristics seem to be a very important determinant of landuse. A particular soil type dictates the carrying capacity of the land for a particular use as determined by its fertility status, texture, waterholding capacity, pH value etc. When there is degradation of soil fertility, the productivity of the land declines and the land is used for other purpose for optimum production. Topography also dictates a specific landuse. Topographical variations cause change in landuse pattern under different physical environment. Climatic change would similarly affect crop production and landuse pattern. Even a marginal change in humidity condition or temperature variation is registered in the change of landuse on a temporal scale.

(ii) Economic : Economic factors are shaped by many attributes. The role of market appears to be significant for a particular landuse pattern. Demand for a particular crop in the market induces its cultivation, but in periods of recession that particular landuse is discouraged and replaced by other type to cater to the need of the market. For example, after the partition of Bengal demand for jute resulted in the extension of jute cultivation in many parts of West Bengal. Many cultivators preferred to grow jute as a cash crop, resulting in decline of food production. But with the loss of demand for jute in the market many of the jute lands were reverted back to paddy cultivation. Changes in the land value are reflected in the variation of landuse. With growing urbanization, the demand for non-agricultural use rises resulting in higher land value. As a result many fertile agricultural lands are thus converted into lands for residential, industrial and commercial uses for higher return. Even the scientific and technological innovations cause a change in the landuse pattern. With the introduction of high yielding variety (HYV) of seeds there has been a spectacular change in the crop landuse in West Bengal and in many parts of India, where large tracts of land are utilized for multiple cropping. The rise in population density, in particular demands more intensive utilization of lands. Intensive farming in some parts of south and south-east Asia has shown that the production per hectare of land is higher than in many developed countries.

(iii) Institutional : Institutional factors are many, controlled by several attributes. These attributes may be social, cultural, behavioural, political and legal. Any change in attribute may determine the landuse pattern. Land tenure system appears to be an important determinant of landuse. Enactment of land reform laws in West Bengal has contributed largely to a positive change in landuse pattern. Earlier in the 'Zemindary' system many marginal lands were not cultivated due to poor return. But with the distribution of such lands to peasant farmers, those are being most efficiently and productively utilized. The change in human skills turns the land more productive and induces a change in the use of the land. The value system and attitude of the people along with the cultural complex sometimes dictate a particular use of the land or prohibits a specific use.

5.2.2. Land types and uses of the land

Utilization of lands is considered very important to cater to the different needs of the inhabitants. Primary use of the land is for agriculture, particularly in the developing countries where the main occupation of the people is farming. In the developed countries and also in the developing countries pressure on land has led the inhabitants to seek other occupation like industries, mining, commerce etc. People also require shelter, for which land is used for residential purposes. High density of population and higher level of occupations have resulted in urbanization since very early days. We find many riverine civilizations in the past, e.g. Babylonian, Indus, Egyptian etc. all were urban based. In the twentieth century the industrial uses of lands have proliferated the growth of towns to shelter large number of working people in and around the industries. The roadways and railways also require an appreciable area of land surface. In recent years demand for more land to build efficient communication lines has sharply increased, as a modern transport network is the precondition for growth and development of economy. In a consumer society as of today, pressure on land has resulted in misuse of lands and land degradation in many parts of the world. But the need of the land for forest generation and scientific management of forests seems to be crucial for the protection of our environment.

Landuse over any place may be agricultural or non-agricultural. Agriculture is the mainstay in a rural society, whereas the non-agricultural uses are dominant in urban landscape. Non-agricultural uses such as urban settlements, site for industries, built-up area for communications, mining and quarries etc. cannot be avoided but may be judiciously planned to ensure most fruitful use of land. Non-agricultural use also includes the forest land in rural set-up preferably on marginal or waste lands.

5.2.2.1. Agriculture

Agriculture is the most wide spread land cover in south Asia. Nearly 45 percent of the total land surface is utilized for crop lands or agriculture in south Asian countries. In India nearly 57 percent of land is utilized for agriculture. The same is true for Bangladesh. These figures are higher than the world average, which is only 11 percent land under agriculture. China on the other hand accounts for only 10 percent cropland, in proximity to world average. Geographical environment rather than population pressure determines the use. The dominance of agricultural landuse in India and Bangladesh is related to the extent of riverine plains, whereas large part of China is mountainous and arid. In China nearly 43 percent of land surface is kept as permanent pasture, whereas India and Bangladesh record 4 and 5 percent of land as permanent pastures respectively. Many developed countries like U.S.A., U.K. and Australia allocate more land to pasture than to crop farming.

5.2.2.2. Housing

Shelter is an essential requirement of the people As the population rises, the need spirals and demands more lands. Though in villages the onslaught on land for space is less, it has become exhaustive in urban landuse. With the growth of towns and cities, more and more agricultural lands are converted into lands for residential and other non-agricultural uses. In a growing metropolis the problem becomes more acute. Demand for land escalates the land value, spiralling rocket high. The land speculators and promoters take such opportunity to transgress the fringe lands, mostly good agricultural lands. In the city of Calcutta the peri-urban wetlands have been threatened due to human interference for settlement. Though legislative protections are there many wetlands are being filled in for residential and other uses.

5.2.2.3. Roadways

Roadways are the lifelines in a city life. The communication network determines the level of development in a city. Each city is characterized by a central business district or C.B.D., which is ususally intimately connected with different parts of the city and its periphery. Roadways thus form an essential part of landuse planning to render the city its mobility. In modern cities roadways are planned and use nearly 10 percent of the city's land surface. But in a city like Calcutta the roadways could only use about 6 percent of land, which is grossly inadequate for the developmental programme. The mass transit facility is a necessary precondition for growth and expansion of a city, which greatly depends on road patterns. In any land use planning the laying and distribution of roadways are therefore given much importance.

5.2.2.4. Forestry

The forest cover in any landuse is related inversely to the croplands. In general south Asia records less forest area than many other developing countries. India has 650 thousand square kilometer of land under forest and this comes to nearly 25 percent of the total land surface. In West Bengal the forest land cover is low, only 0.01 ha per capita. The role of forests in the ecosystem is well understood. In landuse planning anywhere in the world suitable actions are taken for afforestation. The forests in many tropical countries are being cleared for extension of agriculture — particularly plantation agriculture and commercial farming by the multinational companies in recent years. Such action has caused degradation of lands, loss of soil fertility and increased soil erosion. Many environmental hazards like floods and droughts are the consequences of such activities.

5.2.2.5. Mineral resources and mining

Minerals are essential for industrialization and provide man with many utilities. In a throw-away or consumer society, the unwise exploitation of mineral resources may lead to resource crunch in coming years, as these are not renewable. However, with innovations in technology and material recycling this problem has been marginally solved. Mining activities result in deformation of the land surface on a large scale and is often considered to be a sort of robbery on the surface of the earth, forcibly taking away materials that cannot be replaced any more. On many occasions fertile agricultural lands, virgin forests and precious water sources are lost and in many situations the mining activities pollute the environment through generation of huge waste materials. With the growing concern for the environmental protection many mining activities have been either restricted or controlled by different regulations. The land use planning of any region therefore recommends scientific and judicious use of land for mining activities.

5.3. Water resource of the earth

Water is most vital for all living organisms. The requirements of water are many : drinking water for animals including man, water for all plants including that for crop production, water for industries and many other essential uses. At present nearly 40 percent of the world's food crops demand irrigated water apart from the natural precipitation, and most industrial processes require large quantities of water for production of utility goods.

Civilization flourished in the riverine flood plains where water was easily and adequately available for human requirements especially for agriculture. Indus civilization, Mesopotamian civilization, Chinese civilization all grew along major river banks and reached the peak of development. Even today all forms of settlements are found near the source of water — river, lake, spring etc. For the last few decades uncontrolled growth of population supplemented by rapid urbanization and industrialization in many parts of the world have greatly increased the demand for water. We must note that human beings use more than 50 percent of the surface runoff for various purposes. The demand for water would reach 70 percent of the surface water by 2025 AD. This will necessarily deplete the amount of water in rivers and lakes. Moreover the water bodies on earth's surface are being increasingly polluted. Such act of humans may seriously disturb the aquatic ecosystems in the near future due to reduction in supply as well as excessive pollution of water. The aquatic ecosystems are essential for supporting life and also for cleaning and recycling of water itself. The wetland ecosystem is considered one of the most productive ecosystems on the earth's surface and therefore demands protection and conservation for the sustenance of life on earth.

5.3.1. Water on earth's surface

Oceans and seas are the vast reservoirs of water and contain nearly 97 percent of water on earth's surface. Only 3 percent of water are present on land surface as rivers, lakes, ponds etc. and as underground water. Water flowing through the rivers is called the *lotic* water. Water found stagnant in lakes, ponds etc. is defined as the *lentic* water. Both lotic and lentic water are freshwater, however different ecosystems develop in them. Water in oceans and seas are saline and constitute a distinct ecosystem, called *marine* ecosystem. Estuarine areas are usually brackish with salinity intermediate between the seas, oceans and the inland sweet water. So in the estuarine areas we find a different ecosystem with many species common to both marine and freshwater bodies.

We know that 97 percent of water are saline and not suitable for human consumption. But such saline water when evaporated and condensed to precipitate on earth's surface through the hydrologic cycle, constitute the most precious sources of fresh water. However, the storage and supply of freshwater appear to be critically low. The status of water on earth's surface can be understood from the table given below.

Table 5.2. Status of water and its distribution (as percent of total = 100)*

All Water (total)	100
Oceans (Saline)	97
Inland (Freshwater)	3
Freshwater (distributed in percentage of total freshwater)	100
Atmosphere	0.035
Rivers	0.030
Lakes	0.300
Soil moisture	0.060
Groundwater, less than 770 m deep	11
Groundwater, between 770-3850 m deep	14
Ice sheets and glaciers	75

* The total amount of water in the earth is estimated at approximately 1.36 billion cubic kilometres.

It can be seen that water suitable for human consumption is precariously meagre on earth's surface and 99.7 percent of all water is not avilable to us for consumption. Only 0.3 percent of water is usable by humans. Again of this usable water nearly 97 percent is stored as ground water and only a meagre amount flows through the rivers. Still such rivers constitute the principal source of water on earth's surface for human use.

5.3.2. Hydrologic budget

We know that water remains in the hydrosphere, lithosphere and atmosphere in different state — water (liquid), ice (solid) and water vapour (gas) respectively. There has been a change of state of liquid water in the hydrosphere to water vapour by the process of evaporation. Subsequently water vapour is converted to liquid water through the process of condensation and precipitation. Water is frozen under very cold condition on the earth's surface to form ice which on melting yields water.

Through the ages there has been either no gain or loss of water on earth's surface. It is presumed that the amount of water that existed on earth million years ago still remains the same. The hydrologic budget given below explains the balancing of water status on earth. There has been a net loss of 0.36×10^{14} cubic metres per year from ocean, which is exactly balanced by a net gain of 0.36×10^{14} cubic metre per year on land.

Table 5.3. Hydrologic budget of the earth.

Source	*Cubic metres/year*
Precipitation on Oceans	3.24×10^{14}
Evaporation from Oceans	3.60×10^{14}
Net loss from Oceans	0.36×10^{14}
Precipitation on Land	0.98×10^{14}
Evaporation from Land	0.62×10^{14}
Net gain on Land	0.36×10^{14}

Thus land surface neither gains any excess water, nor do the oceans dry up due to loss of water. The excess precipitation that drips, seeps, and flows on the land goes back to the sea. So we must understand that if there is contamination of water on land by pollutants, some of it will ultimately reach the sea. Thus the water of the oceans becomes polluted from the run-off polluted water from land.

5.3.3. Status of water use on earth's surface

It is noted that the source of fresh water on earth's surface is precariously low. Only 3 percent of water is available as fresh water. As stated earlier, only one-tenth of that (i.e. 0.3 percent) is usuable by man. Throughout the world with tremendous pressure of population, rapid pace of urbanization and industrialization demand for fresh water resource has alarmingly increased. The water withdrawal has nearly tripled during the period 1950 to 1995, from 1365 cubic kilometre per annum to 3760 cubic kilometre per annum. Consequently there has been a decline in availability of fresh water on earth's surface, particularly a marked decline of ground water and loss of aquifers due to overhauling. In many cities the water table or the piezometric level has dropped critically; in some cases recording a drop of 30 metres in the last 40 years.

CHAPTER VI

AIR, NOISE AND ODOUR POLLUTION

We have already discussed in Chapter II, the composition of air, the roles of the constituent gases and the regeneration of important gases through the natural cycles. In this chapter, emphasis has been given on the effects of changes in air composition, specially local air composition, because of admixture of polluting substances, the "green-house effect" and "green-house gases", ozone-depleting substances and possible control measures for the same. As because air is the medium of transport of sound and odour, the topics on noise pollution and odour pollution are also included and discussed in this chapter.

6.1. Air : an important resource of the earth

The cover of air that surrounds the earth is crucial to our existence. All terrestrial organisms — flora and fauna including the human beings live in this sea of air like the aquatic animals do in the seas and oceans. Our existence depends on this unique and intricately balanced mechanical mixture of gases. As such, any change or disturbance in the composition and quality of this wonderful natural resource would adversely affect not only the humankind but also the biosphere as a whole.

An average human being requires for breathing about 14 kg of air every day. An average healthy person can survive without food for 3 weeks, without water for 5 days but not even 5 minutes without air. Pollution or loss of cleanliness and integrity of such an essential resource would therefore have the most serious consequences. Air is actually becoming increasingly unclean and polluted primarily by human activities and the detrimental effects have started to show up in a very big way and the situation has now become a matter of serious international concern. The danger of steadily increasing air pollution, according to many environmentalists, will be no less than that of a nuclear warfare, and unless remedial measures are taken up with utmost seriousness, a catastrophe of great magnitude in the present biosphere is almost certain.

6.1.1. Air pollution : definition and classification

According to the definition given by the World Health Organization (WHO), "Air pollution is mixing of some substances in the ambient air in such concentrations that a situation arises in which man and his environment is badly affected".

A number of definitions of air pollution besides the one given above have been put forward. A combined more explicit definition may be given in the following manner :

If the natural proportional amounts of the constituents of air become changed due to various reasons or if some substances, such as dust particles, smoke, gases or vapours, coarse or fine particulate matters including solid or liquid particles get mixed with air in such amounts and concentrations that the functional activities of flora and fauna in the ecosystems of the earth are disturbed and badly affected then that air may be termed as polluted.

Air pollution may be broadly classified under three categories.

(i) **Air pollution by gaseous substances :** Some gaseous substances being emitted in the atmosphere make air polluted, that is why such air pollution is called gaseous air pollution. Some gases are identified as primary air pollutants, these are carbon monoxide (CO), sulphur dioxide (SO_2), oxides of nitrogen (NO_x) and different hydrocarbons. Some other poisonous gases, such as ammonia, hydrogen sulphide, chlorine, fluorine, phosgene etc. may also get mixed with air sometimes rendering the air polluted mainly locally. Some primary air pollutant gases may, however, reacting chemically among each other, may produce an additional pollutant gas — tropospheric ozone is such an example.

(ii) **Air pollution by particulate matters :** Different types of coarse or fine particles suspended in air eg. dust particles, fly-ash, particles of metals or their compounds, different types of carbon particles, liquid droplets such as acid mist may render air detrimental to the flora and fauna. Air polluted in such a manner due to presence of particulate matter is known as particulate air pollution.

(iii) **Air pollution by radioactivity :** Some radioactive substances may mix in air and render it polluted, detrimental radiation emitted from a radioactive substance may be termed air pollution due to radioactivity. Examples of some radioactive air pollutants are strontium of mass number 90 (^{90}Sr), cesium of mass number 137 (^{137}Cs), carbon of mass number 14 (^{14}C) etc., some of which may be due to accidental leakages from nuclear power sources or nuclear wastes.

6.1.2. Sources and factors responsible for air pollution

The sources responsible for emission of air pollutants may be broadly classified under two heads viz. natural and anthropogenic or artificial. The natural sources are forest-fire, volcanic eruptions, putrefaction of dead bodies, cosmic dust particles, dust-storms, salt particles getting mixed with air due to evaporation of sea-water or natural photochemical reactions taking place in the upper or lower atmosphere etc. are some of the natural sources of air pollution.

But it is the anthropogenic or man-made sources of air pollution which are of concern to the environmentalists. About 50% of the total pollution that has occurred since the time the humans learnt to use fire till the present time has taken place in the phase of industrial revolution, specially from the period of second world war onwards with rapid industrialization and urbanization in different parts of the world. Hence, it is essential for us, to be well apprised of the anthropogenic sources of air pollution. Some of such sources are outlined hereunder.

6.1.2.1. Industries

Gaseous and non-gaseous substances emitted from various industries may render air polluted through mixing with it. For example, gases such as sulphur dioxide and carbon monoxide and fly ash particles may be emitted from fossil fuel (coal, petroleum, natural gas etc.) burning factories, thermal power plants etc.

Acid producing industries emit air pollutants such as sulphur dioxide, sulphur trioxide, different oxides of nitrogen, chlorine, hydrogen chloride, phosphorus pentoxide, gaseous fluorides etc.

Metallurgical industries emit sulphur dioxide, carbon monoxide, various metal-oxides fluorine etc.

Sulphur dioxide, carbon monoxide, nitrogen dioxide, formaldehyde, kerosene etc. are emitted by petroleum refineries.

Cement and asbestos industries produce various coarse and fine particles. Some heavy metals or metallic compounds emitted from electroplating industries may also mix with air rendering it polluted.

Besides these, many other pollutants, gaseous or non-gaseous, such as hydrogen sulphide, hydrogen cyanide, lead or its compounds, may pollute air through mixing with it. Moreover in any industry where fossil fuels are used, huge amounts of carbon dioxide gas are emitted in air. Although carbon dioxide is not a poisonous gas an increase in its amounts as a green house gas may act as an indirect air pollutant.

Generally, lack of proper pollution control arrangements in industries is responsible for air pollution from industries.

6.1.2.2. Fumes from different types of motor vehicles

The air pollutants, which are emitted from the engines of different types of motor vehicles, such as buses, trucks, taxis, cars, scooters, three wheelers etc. due to combustion of fuels (petrol, diesel etc.), are carbon monoxide, oxides of nitrogen, sulphur dioxide, unburnt hydrocarbons, polycyclic hydrocarbons, carbon particles, lead or its oxides etc. Due to a continued reaction of the oxides of nitrogen with oxygen of air, ozone gas is formed which is also an air pollutant. Ozone reacts with the hydrocarbons in the presence of sunrays to produce photochemical smog containing many air pollutants such as various aldehydes and ketones, peroxy acyl nitrate (PAN) etc. Air pollution is generally maximum due to emission of such pollutants from motor vehicles and as the number of motor vehicles running through the towns are quite large compared to the number running through the rural areas, the problem of air pollution from such sources is particularly acute in the urban areas. It has been estimated that of the total air pollution taking place in the major cities of India, about 50% is due to emission of pollutants from motor vehicles, about 30-35% due to such emission from different industries and the remaining 15-20% due to other sources.

The main cause of vehicular pollution is due to incomplete combustion of fuels in the engines of such vehicles and the pollution problem becomes acute when the engines are old or they are not properly maintained. Besides, lack of using pollution control devices in the engines and use of leaded petrol (i.e. petrol admixed with lead tetraethyl) as a fuel are responsible for causing vehicular pollution.

6.1.2.3. Industrial and domestic sources

Due to combustion on a very large scale of wood and fossil fuels, specially coal, in hotels, restaurants and for domestic pruposes, there is increased air pollution. Garbage from domestic, institutional and market sources on putrefaction could be responsible for such air pollution along with odour pollution. In our country in many cities a portion of the garbage remains unremoved throughout the day, problem is created mainly due to fermentation of this portion of the wastes. In some cases, again, solid wastes on being burnt produce organic or inorganic substances which are recognized air pollutants.

6.1.2.4. Agricultural activities

Air pollution may be caused due mainly to two types of agricultural activities : (i) Clearing of forests and crop residues by burning which results in the emission and mixing with air of carbon monoxide, carbon particles, carbon dioxide etc. (ii) Due to spraying of pesticides, herbicides, chemical fertilizers on the agricultural lands, such additives may mix with air through wind and pollute the air.

This type of problem of air pollution is naturally acute in the rural areas where another prime source of air pollution is the brick fields from where poisonous carbon monoxide is emitted in air. In recent times, however, many rural areas have practically been turned into semi-towns and many of the sources of air pollution in cities are also present in those areas.

6.1.2.5. Destruction of forests

The forests and the trees play a very vital role in keeping the air pure, because the green plants, through absorption of carbon dioxide from air and emisson of oxygen into it during photosynthesis, help in the maintenance of appropriate proportion of those two gases in the atmosphere. Besides, the plants can absorb some pollutant gases from the atmosphere. But the forest resources are disappearing rapidly from different parts of the world, particularly from the third world countries due to various causes such as clearing of forests for using forest lands as agricultural ones with a view to meeting up the growing demands for food, housing etc. of an increasing population, use of wood in a large scale as a fuel in different industries, in making sleepers in the rails, for rapid urbanization etc. The problem of air pollution is becoming acute for such destroyal of forests at random. According to a report of UNEP, about 27 million hectares of forests including 11 million hectares of tropical forests are disappearing every year on an average throughout the world. In Africa alone about 3 million hectares of forests are denuded every year. In India, the forest area comprises only 19.5 per cent of the total land area of the country, when the minimum forest area should be 33% of the total area..

During the course of our discussion on the different sources of air pollution we observe that the prime causes of air pollution are the same as the fundamental causes of environmental pollution in its entirety; the causes are rapid growth of population, rapid and somewhat unplanned urbanization and industrialization, wide application of new and newer technologies.

Due to a rapid growth of population, urbanization and industrialization are taking place in many instances in a somewhat unplanned manner. In the coming century every 3 cities out of 5 comprising a population of one million or more will be there in the third world countries and it can well be presumed from our present experience that it would hardly be possible to make proper management of many of these cities. Various factories and industries have been developed in populated areas or highly populated residential areas have been developed near pre-developed factories and industries. The pollutants emitted from these industries are directly creating problems of public health in such residential areas. With an increase in population in the cities the number of motor vehicles is increasing, the running of which through very limited road areas is not only causing acute pollution problem, but also frequent traffic jam.

6.1.3. Effects of air pollutants on human health and on flora and fauna

Air may get seriously polluted if various gaseous and particulate pollutants emitted from different sources mix continuously with air and inhaling such polluted air may cause chronic and serious illness and sometimes even death. Polluted air may be detrimental to growth and development of many plants also. Air pollution may cause damage to monuments and palaces of historical importance through corrosion. In the following table, the harmful effects of some air pollutants are briefly described

Table 6.1 : Major air pollutants and their detrimental effects on public health and on other cases

Air pollutants	Detrimental effects	Remarks
Carbon monoxide gas	It reduces the oxygen carrying capacity of haemoglobin of our blood cells. Its presence even in very small amounts in air may cause headache, breathing trouble, drowsiness, vomitting tendency. If present in higher concentrations in air, it can cause even death reducing supply of oxygen in blood. If one inhales air containing 1 volume of carbon monoxide in 1000 volumes of the air (0.1%), one would die at once. It is dangerous for cardiac patients and may accelerate their death.	This gas is present in the smoke of a burning cigarette also. Hence similar dangerous effects may be there on the smoking. Around 350 million tonnes of this gas are emitted every year on an average in the atmosphere from different sources.
Sulphur dioxide gas	In contact with air containing this gas there is irritation of our eyes, there is a burning sensation within the respiratory tract. The gas can create diseases related to ear, nose and throat, pulmonary diseases, bronchitis, asthma, and lung cancer. Due to a prolonged reaction with oxygen and moisture of air, it can produce acids (mainly sulphuric acid) which are more harmful than the gas itself. It may thus be responsible for acid-	In the autumn of 1952 there was a fatal smog in London which caused death of about 4000 persons within a few days. Concentration of sulphur dioxide gas in the air of London increased to about six times its normal concentration at that time and this was mainly held responsible for the London smog disaster. Through acid rain this gas may corrode the walls of palaces, monumnets etc. of historical importance.

	rain. Sulphur dioxide and acid rain produced from it may reduce badly the production of crops. The green colour of the leaves of plants may be bleached in contact with sulphur dioxide, as a result of which the rate of photosynthesis may be decreased.	Production of cotton, wheat, barley, apples may be most badly affected. The gas may be responsible for the formation of smog by mixing with air — particularly in winter in many cities.
Oxides of nitrogen (gaseous)	They cause irritation in the fibres of the lungs and in mucous membranes. They can create different diseases such as bronchitis, pneumonia and other pulmonary diseases. The acids (nitrous and nitric acids) produced through a reaction of these oxides with oxygen and moisture of air may be responsible for various diseases related to our respiration, digestion and nervous systems. When there is rain the gases may cause acid rain. If there are 5 to 6 parts of nitrogen dioxide per million parts of air (5-6 ppm) inhalation of such air for 2 to 10 days, may even cause death. The power of resistance to some diseases, such as influenza may be reduced or lost due to continuous exposure to these gases. There may be detrimental effects of the gases on plants also. The leaves may be damaged and rate of photosynthesis may be lowered and growth of the plants may be impeded, (as has been observed in beans, tomato etc.)	
Ammonia gas	In contact with the gas the eyes may be badly affected. It may cause irritation to the respiratory tract.	
Hydrogen sulphide gas	It causes headache and vomitting tendency, irritation of the eyes and throat and loss of appetite. Inhalation of air containing high concentrations of the gas may cause diarrhoea, bronchial asthma, and even death due to respiratory failure.	White paints of oil paintings may, in long contact with air containing hydrogen sulphide, turn brown or black.

Hydrogen cyanide gas	Inhalation of air containing this gas causes drying of throats, headache and impairment of vision and may cause death by damaging the nerve cells.	
Arsine (gas)	It causes damage to kidney and liver and causes hepatites (jaundice), breakdown of haemoglobin of blood may even cause death.	
Chlorine gas	Causes irritation in the respiratory tract, and causes breathing trouble, may create conjunctivities — a disease of eye.	Believed to be one of the causes of acid rain on being dissolved in rain water.
Ozone gas	It can cause headache, eyediseases, reduces resistance to diseases, can cause chronic bronchites, haemarrage of the lungs and lung cancer. Ozone may have damaging effects on plants and can cause reduction in crop production. The green leaves of plants turn yellow in contact with this gas (which is called chlorosis).	The fibres of cotton, nylon, ployester etc. are attacked with ozone. The articles made of rubber become brittle in contact with ozone.
Phosgene or carbonyl chloride (gaseous)	Induces a burning sensation in our respiratory tract and causes fatal diseases of lungs, there may be deposition of water within the lungs.	
Gaseous hydrocarbons	At high concentrations, they may cause acute breathing trouble and serious damage to the lungs. Hydrocarbons such as benzene, benzopyrine are carcinogenic. The photochemical smog, which is formed due to a chemical reaction among the hydrocarbons, oxides of nitrogen and oxygen of air, is a cause of ENT (ear, nose and throat) diseases; hydrocarbons, such as ethylene, acetylene, propylene etc. and the various substances formed from them due to photochemical reactions impede growth of plants by reducing the rate of photosynthesis.	

Suspended particulate air pollutants (dust, smoke, soot, lead, ash etc.) collectively called SPM i.e. suspended particulate matter)	Cause ENT diseases and serious damage to the lungs. The finer particles are more detrimental; the coarse particles being arrested within the nasal cavities. The most harmful particulate pollutant in the smoke from the engines of motor vehicles is lead (or its compounds) which badly damages the brain of the children in particular, causes nerve diseases and impedes creation and formation of the red corpuscles of blood, high concentrations of lead may cause decomposition of haemoglobin of blood. Other metallic particles, or their compounds such as cadmium, beryllium, cobalt etc. may remain suspended in air and being inhaled may cause various pulmonary and cardiac diseases. Mercury may seriously damage the nervous system and may cause death. Silica (sand particles), asbestos fibres, different types of carbon-particles may get into the lungs causing serious damage. Carbon as soot may be deposited within the respiratory tract and may cause various diseses of ear, nose and throat (ENT). The floating or suspended particulate air pollutants may have direct or indirect harmful effects on plants. Many particulate air pollutants being washed with rain water may fall on the soil and affect soil fertility. These particulate pollutants close the stomata of the plant leaves and reduce the rate of transpiration and photosynthesis of plants. As a result, growth of plants may be impeded and crop production may be reduced.	Lead or its compounds being heavy come downwards in the air and it has been observed that they have a maximum concentration in air at a height of about one metre from the ground. For this children are most badly affected by such poisonous substances, because their noses are at such a height level and they absorb large amounts of these in their body alongwith the inhaled air.

It is to be mentioned, in this connection, that according to a report of the World Health Organization (WHO) about one-tenth of the total population of the world (presently exceeding 6 billion) live in such cities where sulphur dioxide concentration in air is dangerously high and about 1.3 billion (130 crore) people in the world breathe in air containing suspended particulate pollutants at concentrations much higher than the dangerous level. Delhi, Mumbai and Calcutta of our country are among the 12 most polluted cities of the world (these are : Bangkok, Beijing, Delhi, Mumbai, Calcutta, Karachi, Los Angeles, Manila, Moscow, New York, Rio de Janeiro and

Tokyo). According to the data furnished by the National Environmental Engineering Research Institute (NEERI), about 1300 tonnes of various pollutants are emitted everyday on an average in the air of Calcutta and Howrah taken together, about 50% of which come from the smoke of motor vehicles.

6.1.4. Some profession-linked (occupational) diseases attributable to air pollution

We have observed that gaseous or particulate pollutants emitted from various sources pollute air. As such, those persons who have to remain very close to those sources of pollution or at nearby areas are worst affected by the pollutants.

For example, the labourers who work in stone-grinding mills, cement industries or rice mills, have to spend a prolonged period within an environment of dust particles containing silica. This silica enters into the nasal cavities, gets deposited in the respiratory tract and lungs causing headache, sinus, breathing trouble and different pulmonary diseases some of which may be fatal. The disease created from silica is known as silicosis.

Similarly, the workers of textile mills may be attacked with sinus, pulmonary diseases etc. due to inhalation of fine textile fibres continuously over a long period. Due to entry of asbestos fibres into body of persons working in asbestos industries there is a possibility of occurrence of a disease known as asbestosis.

Persons who work in petrol pumps or in motor garages, are exposed to toxic vapours of petrol or diesel oil for a prolonged period. As a result, many of these persons may feel a loss of appetite, headache, breathing trouble. The solvents which are to be used for colouring the motor vehicles quite easily evaporate and may cause harm to the garage workers by attacking their eyes, or in other ways. If there is lead in the petrol or in the paint, the poisonous lead may enter into the body and may cause nervous diseases. The garage workers may be attacked with ENT or pulmonary diseases due to prolonged exposure to hydrocarbons and acid vapours from the batteries.

The workers of pesticides producing industries or the persons engaged in spraying the pesticides in agricultural fields or in other places may suffer from headache, irritation of eyes, drowsiness, vomitting tendency, stomach ache etc. The pesticides such as D.D.T., gammaxine, malathion, etc. may have long standing harmful effects on the factory workers, persons handling them and users if strict precautionary measures are not undertaken.

Those who are entrusted with the job of operating the x-ray machines or those working in radio-therapy units in hospitals, nursing homes or in laboratories, may be exposed to the harmful rays or radioactivity for a prolonged period and they may thus be the victims of radioactive pollution.

The large number of workers in various chemical industries may thus be the victims of profession-linked diseases, because quite a number of chemicals produced in these industries may be poisonous or detrimental to health which emphasizes the need to follow all possible protective measures.

6.1.5. Smog and acid rain : two accompanists of air pollution

These two phenomena arising out of air pollution may have some dangerous effects on the flora and fauna and on other objects also.

6.1.5.1. Smog

In the autumn of 1952, the city of London remained covered with a thick envelope of fog continuously for five days. Many persons belonging to all the age-groups fell ill and around 4000 persons lost their lives due to that fatal fog. Later, it was revealed that the fog got admixed with poisonous gases containing mainly sulphur dioxide emitted from industries and motor vehicles. An English physician named the mixture of smoke and fog as smog (smog = smoke + fog).

This is not the single or earliest example of smog disaster. Similar event occurred in 1930 in the Mass river valley of Belgium and in 1948 in the city of Donora in the Pennsylvania State of the U.S.A., although the damaging effects were much less intense than that in the London smog disaster. The Los Angeles city of the U.S.A. and some cities of Japan are quite often covered with a black cloud of smog.

In our cities also, experience of smog is not unknown and Delhi, Mumbai and Calcutta are often experiencing smog in winter.

Besides causing detrimental effects on public health, smog can have harmful effects on other animals and plants. Articles made of rubber and nylon may become brittle due to smog. Smog can damage palaces and monuments of historical importance.

The explanation for the formation of smog as given by the meteorologists may be described in a simplified way as follows.

Under normal conditions, the temperature of the ambient air layers decreases with height. Normally, the lower layers of air on being heated move upwards and the fresh and pure air from upper layers comes downward. But under certain conditions there may be an inversion of this temperature creating a different situation. During winter, under the very cold climatic condition the air layers at the ground level become too much cooled and condensed to move upward and remain near the ground. Air from the upper layers, having a higher temperature, cannot travel downward in such a situation. Such inversion of temperature is the first factor responsible for the formation of smog, the second factor is the mixing of the poisonous gases emitted from industries and motor vehicles with the foggy air. Thus fog and smoke combined together form the smog.

Sulphur dioxide gas has been identified to be the prime constituent of smog. During the London smog catastrophe of 1952, concentration of sulphur dioxide in the air of London increased by six-fold over the concentration of the gas under normal conditions. The city of

London has always remained famous for its fog, but it is from the middle of the twentieth century that the problems arising out of such fog became more acute. In 1956, 1957 and 1962 also the city of London was covered with a thick envelope of smog, however, the situation has improved considerably during the last decade.

In the city of Los Angeles in the U.S.A., smog is formed, on an average for about 270 times in a year. The chief constituents of the smog formed there are the oxides of nitrogen (NO_X) and ozone, besides there are various compounds formed through a photochemical reaction of these two with the hydrocarbons emitted from the engines of motor vehicles. Such a smog is, therefore, termed as a photo-chemical smog. Eyes, nose and respiratory tract are attacked by such a smog. Plants are also badly affected with this type of smog. The highest number of motor vehicles in the world ply in the streets of Los Angeles. The mixing of huge amounts of smoke emitted from the very large number of motor vehicles with fog causes this high incidence of fog and according to noted environmentalists it is not unexpected or surprising.

In fact, the problem of smog is acute today in many cities of the world. There is a warming in this regard from many corners. According to Morris Neuerberger, meteorologist of California University, one day the entire world will be covered with a black smog and the human civilization will come to an end. We should not be alarmed of such warning right now, but there is no difference of opinion that a definite plan should immediately be taken up to combat this problem.

6.1.5.2. Acid rain

In simple words acid rain is acid mixed with rain water. Some acidic gases mixed in air, such as sulphur dioxide , some oxides of nitrogen etc. on prolonged reaction with oxygen and mositure of air produce various acids. When there is rain, these acids (along with some suspended particulate substances) being dissolved in rain water come down on the earth and may render the soil or water of surface water bodies acidic. Acid rain is thus an outcome of air pollution.

There may be some detrimental effects of acid rain on the flora and fauna; buildings and monuments of archeological importance may also be badly effected by acid rain.

As a result of acid rain, the soil may turn acidic adversely affecting plant growth, the fertility status of the soil may be reduced or totally lost. The forests and other vegetation may also be badly affected by acid rain. In West Germany a large part of the forests was severely damaged as a result of acid rain. The forests in North America, Canada, Europe and Japan were affected by acid rain. Production of some vegetables, such as peas and beans, potato, raddish etc, may be reduced by acid rain, growth of pine, eucaliptus etc. may also be impeded.

There may be harmful effects of acid rain on some animals also. It has been ovserved that breeding of moths is impeded by acid rain. In many places of the world, such as in Norway, acid rain has reduced the number of different types of birds. In our country also the water of the lake of Bharatpur Bird Sanctuary is turning acidic in contact with sulphur dioxide gas of the air, as a result the migratory birds are coming to this place in fewer numbers . This was the opinion of Salim Ali, the famous ornithologist of India. Acid rain may turn acidic the water of ponds, rivers, lakes etc. In such acidic water the eggs of the fishes may be destroyed, the physiological processes of the fishes may also be affected and as a result the water reservoir may be fishless ultimately. If the soil below the water and at the sides of the water source (lake, pond etc.) be basic in nature, the effects of acid rain on the aquatic animals may not be that much serious, but if such soil contains some acid soluble metals which are detrimetal to the fishes and other aquatic animals, the effects may be fatal. For example manganese or aluminium from the soil may dissolve in acidic water and may be harmful to the fishes. Mercury compounds may also mix with acidic water and may thus cause danger to the aquatic animals. In fact, many lakes in U.S.A., Sweden etc. have become fishless as a result of acid rain.

The effects of acid rain on the public health and on the animals may be dangerous. Acid rain contains mainly two acids — sulphuric acid and nitric acid — which are harmful to the lungs and the respiratory system, they may cause lung cancer, and damage the digestive and nervous systems. There may be several other dangerous air pollutants other than acids in the acid rain which may also be harmful to public health.

Due to acid rain, some heritage buildings and monuments of architectural and historical importance are in danger in different parts of the world. Acids of the acid rain attack marble, limestone etc. of which such architectures are made of. For example, due to sulphur dioxide created acid rain, the Lincoln Statue of Washington, U.S.A., Needle of Cleopetra, Acropolis of Greece, British Parliament House in London etc. are in danger. In India a few years back, signs of corrosion on the walls of Tajmahal were observed. According to the environmentalists this was due to the presence of sulphur dioxide in high concentrations in the air of Agra which would react with the moisture of air form sulphuric acid and corrode the marble of the walls of Tajmahal. Sulphur dioxide emitted from the petroleum refinery situated on the other side of the Jamuna river was held primarily responsible for such corrosion. This 'stone-cancer' of Tajmahal has since been checked through adoption of suitable control measures. As the concentration of sulphur dioxide is increasing in the air of Delhi, there may be danger of corrosion of Red Fort and similar other historical buildings and monuments made up of stones. In Calcutta also, architectures such as the marble-built Victoria Memorial Hall may be in similar danger in the near future.

Generally rain water is slightly acidic, carbon dioxide of air gets dissolved to some extent in this water forming carbonic acid. Such slight acidity of rain-water is not detrimental because the acidity is practically neutralized by the basic dust particles suspended in air. But if there are acidic oxides such as sulphur dioxide, oxides of nitrogen etc. in relatively large amounts in the air, the rain water may become sufficiently acidic for causing the harmful effects mentioned above. Therefore, control of acid rain has been a matter of great concern to environmentalists all over the world.

6.2. Green house effect

In the temperate countries some economically important plants that cannot grow outside at a very low temperature during the winter are grown in glass-walled and glass-roofed growth chambers (known as glass houses) exposed to sunlight. Glass houses are also used in subtropical regions during the winter months and in relatively cold high altitude areas for high-value horticultural annual crops including flowers on a commercial scale as well as for research work especially for breeding of new varieties and crop physiological and pathological studies. Temperature within the glass house rises because the glass of the roof and walls though it allows entry of sunlight with little obstruction, resists the escaping of the reflected light of longer wavelengths rich in infra-red rays resulting in a heat built-up. Such glass houses are called green houses as the light and heat within such houses prove very effective for profuse growth of green plants although the outside is very cold and often snow-covered and barren.

The property of trapping heat by carbon dioxide and some other gases of the atmosphere is similar to the glass cover of a green house that resists the escaping of heat radiated from inside the house. As such, these atmospheric gases are called the green house gases that resist the escaping of radiated heat from the earth by absorbing infra red rays and partially reflecting the trapped heat back to the earth's surface. This phenomenon is therefore called the green-house effect in which certain atmospheric gases act in a manner similar to the glass cover of a glass-house (earth itself behaving as a green house).

It has been mentioned earlier that if the amount of carbon dioxide and other green house gases would increase in the atmosphere, the temperature on the surface of the earth and that of the layers of air adjacent to the surface would increase, on the other hand the global temperature will decrease with a decrease in the amount of the green house gases in the atmosphere. In fact, the amount of almost all the green house gases in the atmosphere is gradually increasing, as a result of which it is predicted that the global temperature would increase and there would be climatic changes on the earth resulting in adverse effects on the ecosystem of the earth. We should, therefore, well apprise ourselves of the green house gases and about the decrease or increase in the amounts of these gases in the atmosphere.

6.2.1. Some possible effects of green house gases

The question which naturally comes to our mind is what may be the impact on the environment if the amounts of the green house gases in the atmosphere go on increasing. In answering the question it may be said that some of the possible effects would be direct and some others would be indirect.

A possible direct effect of an increase in the amounts of green house gases in the atmosphere would be an increase in the average temperature of the earth's sufrace and its adjacent layers of air. But there is a difference of opinion among the scientists regarding the extent to which such temperature would increase and how rapidly such a change in global temperature would take place. In fact, scientists are trying to make predictions on the basis of different models, not a single model of the changing earth-system, that is why their predictions differ to some extent. Besides, a possible counter-effect of the green house effect may be in operation in the atmosphere for which the scientists are somewhat hesitant in making confident predictions. There is a possibility of accumulation of particulate substances in increasing amounts in the atmosphere which may have some sort of screening effect on the path of the sunrays falling on the earth, the particulate matters partly absorbing and partly reflecting back a portion of the sunrays. As a result, the available solar heat to the earth may be reduced to some extent resulting in a cooler earth-surface. But there is no difference of opinion among the scientists about the fact that the global-temperature is actually increasing and will continue to increase in the future in spite of the possibility of the opposing effect to the green house effect being in operation in the atmosphere. The question remains regarding how repaidly this temperature will rise.

At present the average global temperature is about 15° Celcius. There has been an increase or decrease in the temperature of the earth in the past. About 18000 years ago during the last ice-age when the amount of carbon dioxide in the atmosphere was about 40 per cent less than the present amount the average global temperature was about 5° Celcius less than the present temperature. About a billion years ago (i.e. the dinosaur age) the global temperature was 4°-5°C higher than the present value. Actually the global temperature has increased by 0.5°C to 1.5°C during the period from 1860 (pre-industrial period) to the current time. According to many scientists, during the middle of the next century when the amount of carbon dioxide equivalent to all the green house gases (from the point of view of the capacity of trapping heat) may be doubled, the global temperature may increase by 1.5°C to 4.5°C on an average.

The predicted rise of global temperature may appear to be not too high, but if it actually increases as predicted, the impact may be very high. It has been apprehended that if the global temperature increases by only 3°C above the present temperature, a situation will arise which the living world did not face during the last 100000 years.

With a rise in global temperature there may be other consequential effects. Some possible effects are discussed below.

6.2.1.1. Possible effects on the climatic conditions

Emission of green house gases in the atmosphere in increasing rates may affect the climate to a large extent.

Due to an increase of average global temperature, water from various sources on earth may evaporate more rapidly as a result of which the overall amount of rainfall may increase. But this phenomenon will not occur evenly in all the parts of the earth, there may be heavy rainfall in some parts and drought in some other parts of the world. In some regions (specially in the tropical zones), the summer may be more prolonged, on the other hand in the north polar regions the temperature of the earth's surface and its adjacent air layers in the winter may be much higher compared to the present situation.

6.2.1.2 Possibility of rising of sea level

If the global temperature increases, the ice-caps and glaciers of the polar regions of the earth (Greenland, Antarctica) may be melted partially, the floating ice on the water of the seas may also melt partially or completely and due to an increase in temperature there may be an expansion of volume of sea water, as a result of which the level of seawater may rise. The sea-level has risen by about 0.15 metre during the last 100 years. According to some scientists, the sea level may rise by 0.5 metre to 1.5 metre (according to others the increase may be 3 metres), if the global temperature increases by 3°C—5°C on an average. As a result, a vast populated low-land area of the world, specially the coastal areas, may be flooded. The problem of rehabilitation of the victims of the flood may become acute in many countries. Besides, fertile agricultural lands of such areas being flooded with salty seawater may become unsuitable for cultivation badly affecting the production of crops. It is not difficult to presume that in case such a situation actually arises the worst sufferers will be the poor countries of the third world.

With a rise of sea water level the low land areas of the deltas will face the maximum probability of being flooded with or being permanently immersed in sea water. A vast area of Egypt, Bangladesh, Sundarbans of West Bengal and low coastal areas of India may be flooded or immersed. About half of the land area of Bangladesh has an elevation of less than 5 metres above the sea level. It has been apprehended that if the seawater level actually rises according to the present prediction, about 18% of the land area of Bangladesh will be immersed in water during the middle of the next century and as a result about 15% of the population of the contry will have to be refugees and at the end of the next century as high as 35% of the population of this country may have to be environmental refugees. Within the coming 300 years the Maldives may be totally immersed in seawater. But a faint ray of hope is there in the prediction of some scientists that the situation may not be so serious.

6.2.1.3. Effects on agricultural production

Whether the production of crops will increase or decrease will depend on several factors such as geographical position and the nature of change of climate of the particular region, extent to which the amount of carbon dioxide in air increases, moisture content and dryness of the soil, nature of the crop etc. For example, it has been apprehended that due to intensive green house effect there may be frequent droughts in summer in the countries of middle latitudes of the north hemisphere, in that event production of crops may decrease in the northern parts of U.S.A. and in the present productive areas of the erstwhile U.S.S.R. On the other hand, the amount of carbondioxide in the atmosphere being doubled and the average global temperature rising thereby, production of wheat may increase by about 33% in the middle European regions of erstwhile U.S.S.R. but the production of barley may decrease to a considerable extent as because higher temperature is unfavourable for production of barley.

An increase in the amount of carbon dioxide in air is favourable for an increasing rate of photosynthesis of plants, therefore increase in carbon dioxide may increase the production of crops in some cases, on the other hand crop production may be reduced in some cases due to dry soil having a higher temperature. There may be acute scarcity of water for irrigation in some places. In some regions, again, production of crops may be decreased due to soil erosion rate becoming faster due to heavy downpour and washing away of fertile top soil reducing thereby the available cropland area. In regions of middle and high latitudes such as the plains of U.S.A., western Europe, north Canada, Siberia, the soil will become much drier, soil-productivity will decrease. Recently it has been predicted that production of crops in India and Pakistan will be reduced by about 30% by 2050.

6.2.2. Possible measures to counter greenhouse effects

Emission of the greenhouse gases at increasing rates may be combated mainly through three types of measures : (a) reducing the emission of the greenhouse gases in the atmosphere (b) prior preparation for adapting with the changing situation in the future and, (c) to undertake intensive research on counteractive methodologies.

6.2.2.1. Reducing emission of greenhouse gases

The key player among the greenhouse gases is carbon dioxide. For regulating its emission in air in increasing amounts mainly two types of measures have been prescribed viz. reducing the use of fossil fuels and conservation of forests along with development of new forests on a large scale.

As because combustion of fossil fuels in huge quantities is the prime cause of increase in the level of carbon dioxide in air, a reduction of such combustion is urgently necessary. We will have to think of alternative fuels such as solar energy, hydrogen or atomic energy, hydro-electricity etc. to reduce to a large extent the emission of carbon dioxide in air.

The large scale destruction of forest resources must be checked and at the same time all efforts should be made to develop new forests. It has been estimated, however, that about 465 million hectares of new forest area are to be developed to absorb the excess amount of carbon dioxide in air each year.

It is worth recalling in this connection that in an international conference held at Toronto in Canada in June, 1988 it was resolved that the industrially developed countries would reduce carbon dioxide emission in air by at least 20 per cent by the year 2005.

The emission of nitrous oxide may be reduced by regulating the application of nitrogenous fertilizers in agricultural lands in such a way that the loss of nitrogen in the form of gaseous oxides is minimum and also by controlling large scale combustion of fossil fuels. The different oxides of nitrogen, produced during combustion of fossil fuels in the engines of motor vehicles and in various industries, react with oxygen of air to produce ozone. Therefore for controlling the emission of ozone in the troposphere it is essential to control the large scale combustion of fossil fuels and to search for alternative fuels.

With a view to controlling the production of chlorofluorocarbons (CFCs) and halons an international treaty was signed in a conference held at Montreal in Canada in September, 1987 which is known as the Montreal protocol. The signatory countries (49 in number) decided that production of CFCs will have to be reduced by 1998 to 50% of the production in 1986. Later, it was realized that merely a reduction of production by 50 per cent is not adequate at all, the production of such compounds should be totally stopped. As such, in the London conference, held in 1990, it was resolved that the production of CFCs must be totally banned by the industrially developed countries by 2000 and by the developing countries by 2010. This decision has been made effective since August, 1992. It is expected that due to such measures the green house effect due to CFCs will be reduced to some extent, although the danger will not be totally eliminated because of the long term effect of CFCs and halons already emitted in the atmosphere. Most of the ozone-destroying CFCs have long life periods of the order of 100 years or more.

To control emission of methane, produced mainly in muddy paddy fields and marshy lands and also by ruminating animals it is necessary to address the socio-economic conditions especially the high growth rate of population in rice-producing countries of the third world. In India, the population has just crossed a billion. It is not possible to reduce the cultivation of rice; in fact more rice will be required to meet the increasing demand for food by the rising population. Switching over to other grain crops by land-shaping (raising low land by digging ponds) is not a practical proposition; only in certain cases water management and other cultural practices may be adopted but on the whole it will not drastically alter the situation. Incidentally the marshy lands are shrinking because of the pressure of population. It is now widely perceived that the role of methane, and in that context the role of the third world countries in the generation of green house gases in particular, has been greatly exaggerated by the developed countries who are far more responsible for the production and release of huge amounts of carbon dioxide, nitrous oxide and chloroflurocarbons into the atmosphere. For example, U.S.A. containing only 5% of world population, is responsible for 23% of the total emission of carbon dioxide in the global atmosphere, whereas India consisting of 16% of world population may be held responsible for only 3% of total emission of the gas in the world. Actually the industrially developed rich countries are responsible for consumption of 80% of the total fuels consumed worldwide.

Hence these developed countries should bear the financial responsibility for implementation of programmes to be undertaken for controlling emission of the green house gases in the atmosphere. The third world countries should be generously helped by such developed countries in the programmes of conservation of forests and development of newer forests. It is actually through a concerted effort of the countries of the north and south of the world that the programmes for control of emission of greenhouse gases and that of global temperature rise may be properly and effectively implemented.

6.2.2.2. Adapting to changed situation

If it is supposed that increasing greenhouse effect along with global temperature rise is inevitable and the consequential other effects cannot be checked, then we should think of ways for adapting to the changed situation and actually such thinking has already been started. As for example, if in spite of all efforts there is a rise of sea-level, an arrangement has to be made for rapid rehabilitation of people living in low coastal areas. Erecting dams to keep away seawater as has been done in the Netherland, or elevating the land of the coastal areas to prevent flooding may be tried but for resource poor third world countries it would be extremely difficult to materialize. For controlling salinity of agricultural lands in the coastal areas new technological innovations will be necessary. For the development of highly salt resistant cultivars for crop production on the saline lands, varieties may have to be developed biotechnologically to replace the existing ones.

Some countries may actually benefit from the possible changes in the climate consequent upon increased carbon dioxide level and global warming. For example production of rice in Japan may be increased by more than 25% on shifting its cultivation from central part of Japan to the northern part of the country. In the cold regions of the earth, if the period of crop-production becomes prolonged and the temperature of the soil and air of the agricultural land becomes higher, there is a possibility of higher agricultural production. Better results may also be obtained by changing the period of crop production. For example in the summer of 1988 the production of crops in the mid-western part of the U.S.A. was largely impeded due to serious drought late in the season and for the first time in the history of U.S.A., production of crops was drastically reduced. On the basis of this experience the farmers there sowed the seeds much ahead of the usual scheduled period and obtained good results. Thus adjustment with the changed situation by changing the place of cultivation, time of sowing keeping with the changed climate, by making arrangement for proper irrigation, using fertilizers in conformity with the soil reactions and adoption of sound management practices may alleviate the situation.

For all these, it is essential to undertake urgently all sorts of preparatory measures, the first and foremost being development of appropriate research-based technologies.

6.3. Green house gases, increase in global temperature and ozone hole

It has been stated in chapter V in the course of discussion on carbon cycle, that the amount of carbon dioxide in the air remains more or less constant if there is a balance between the amount of carbon dioxide emitted or given up in the air due to various processes and the amount of it absorbed by different sources. But, due to various reasons, this balance is being disturbed. The amount of carbon dioxide in the atmosphere (at present about 0.035%) is gradually increasing. Large scale destruction of forests and excessive combustion of wood and fossil fuels (coal, mineral oil, natural gas etc.) is responsible for the progressive increase of carbon dioxide in the atmosphere. The relative amount of carbon dioxide in the atmosphere has increased by about 25%–30% in comparison to the amount present just before industrial revolution (from the year 1860) as a result of a large increase in the use of coal, oil and gas as fuels in the industries. At present carbon dioxide is increasing in the atmosphere at an approximate rate of 0.4 per cent per year on an average. If the amount of carbon dioxide in the atmosphere is going to increase at such a rate, the effect in the environment may be dangerous.

A special property of the atmospheric carbon dioxide is that the gas is not obstructive to the rays of the sun falling on the earth, but it absorbs the reflected long wave length infrared rays— radiated as heat from the heated surface of the earth. A portion of the heat trapped by carbon dioxide (and several other gases in the air) is reflected back to the earth's surface. Carbon dioxide of air, water vapour and a few other gases thus regulate the temperature of the earth. The trapping of heat radiated from the surface of the earth and maintaining a rather high temperature by carbon dioxide, water vapour and a few other gases of the air is called, Green House Effect because an identical situation (heat trapping) occurs in a glass house used for growing green plants in a cold climate (also called a green house). The gases naturally present in air or artificially mixed with it which have the property of directly or indirectly raising the temperature of the earth are known as 'Green House Gases' (GHGs). Besides carbon dioxide the principal green house gases are water-vapour, methane, nitrous oxide, tropospheric ozone, chlorofluorocarbons and halons.

6.3.1. Carbon dioxide

The most effective greenhouse gas in the atmosphere is carbon dioxide. Among the components of air, carbon dioxide being the heaviest one, density of carbon dioxide in tropospheric air is very high, moreover the amount of carbon dioxide in air being larger compared to the other green house gases except moisture, carbon dioxide plays the most vital role in trapping the heat radiated from the earth. In fact, carbon dioxide is responsible for about 60% of the green house effect due to anthropogenic sources. The amount of carbon dioxide in air is increasing rapidly mainly due to two reasons : (a) combustion on a large scale of wood and fossil fuels, such as coal, mineral oil and natural gas and (b) rapid destroyal of forests, forest fires or forests being cleared by burning for obtaining agricultural land or for housing.

As a result, due mainly to anthropogenic activities about 22 billion tonnes of carbon dioxide or 6 billion tonnes of carbon are emitted per year on an average in the atmosphere, only 50% of this amount is absorbed by plants and oceans, the remaining portion is accumulating in the atmosphere. It has already been mentioned earlier that as a result of this, the amount of carbon dioxide in the atmosphere is increasing at the rate of 0.4 per cent per year on an average and if the amount continues to increase at such a rate the amount of carbon dioxide in the atmosphere my be doubled (0.07%) by the middle of the next century. It has been estimated that during the period from pre-industrial revolution to the present time the amount of carbon dioxide in air has already increased by about 25-26%.

6.3.2. Methane

Methane is produced mainly in paddy fields and marshy lands by rotting and decompsition (putrefaction) of plants caused by bacteria and under almost anaerobic conditions. It is also produced by the fermentation of urine and faeces of cattle, pigs etc. and due to putrefaction of dead animals under anaerobic conditions. As such, the methane of air comes mainly from organic sources. At present there are about 1.7 parts of methane per million parts of air (1.7 ppm) and its amount in air is increasing by 1.1% per year (rate of increase) on an average. The power of trapping of heat by methane is about 25 times than that of carbon dioxide moleculewise. But its amount in air being much lower than that of carbon dioxide, its contribution to the green house effect is within 15-20%. Increase in the amount of methane parallels the growth of population. Contribution of methane is next to that of carbon dioxide to the green house effect. India is largely dependent on agriculture and live stock and contributes to the extent of about 14 per cent of the total amount of methane emitted in air.

6.3.4. Nitrous oxide

Nitrous oxide is produced through various natural processes, such as forest-fire, reaction in soil of a special type of bacteria, due to slow and spontaneous oxidation of crop residues or due to addition of nitrogenous fertilizers to the soil. This is also produced due to large-scale combustion of fossil fuels, particularly mineral oils used as a fuel in the large number of motor vehicles. The amount of this gas is increasing in the atmosphere at a rate of about 0.3 per cent per year. If the concentration goes on increasing at this rate it is apprehended that the amount of the gas in air would be 30-35 per cent higher than that present just before the industrial revolution. Its contribution to the greenhouse effect is about 4-5 per cent. From the point of view of trapping heat a molecule of nitrous oxide is 250 times more effective compared to a molecule of carbon dioxide.

6.3.5. Chlorofluorocarbons (CFCs)

These compounds are artificially prepared and they are used for different types of refrigeration (in motor cars, refrigerators, cold storage etc.) as refrigerants, as propellants for spraying cosmetics, (aerosols) as insulators, as foams in cushions, mattresses, sofa, etc. This class of compounds plays a major role in destroying the stratospheric ozone layer and the compounds act as green house gases in the troposphere. The two most widely used compounds of this class are marketed as CFC-11 and CFC-12. The power of trapping heat by a molecule of the former is 17,500 times higher than that of a molecule of carbon dioxide and such power of the latter compound is 20,000 times the power of carbon dioxide moleculewise. The life-period of these compounds is quite high (100 years or more). The concentration of these compounds is increasing in the atmosphere at a rate of about 5% per year. The contribution of CFCs in the green house effect is about 10-12 per cent.

6.3.6. Tropospheric ozone

Tropospheric ozone is very much effective as a greenhouse gas and it is an air pollutant too. Oxides of nitrogen produced due to combustion of fossil fuels in the engines of motor cars and in various industries react with oxygen of air to produce this gas. This gas is increasing in the atmosphere at a rate of about 0.5-2% per year on an average.

6.4. Ozone hole of the atmosphere

Stratospheric ozone layer : Ozone layer of the atmosphere is stretched over a distance of 10-35 kilometres from the ground. Under the influence of the ultraviolet rays of the sun oxygen (O_2) of the atmosphere decomposes to oxygen atoms (O), and one oxygen molecule combines chemically with an oxygen atom to form a ozone molecule of three oxygen atoms as shown below :

(i) one oxygen molecule (O_2) $\longrightarrow$ two oxygen atoms(O + O)

(ii) one oxygen molecule (O_2) + one oxygen atom (O) $\longrightarrow$ one molecule of ozone (O_3)

6.4.1. Role of the ozone layer

Although presence of ozone in the ambient air (tropospheric ozone) is harmful to public health, the stratospheric ozone layer has a specific positive role because this ozone layer absorbs 99% of the ultraviolet rays of the sun, harmful to the living organisms. The ozone layer of the upper atmosphere is, thus, saving the entire living world from the ultraviolet rays of the sun by covering the earth as an umbrella.

Ozone hole : But it is reported that recently this ozone layer has been damaged in some parts of the world. The possibility of the ultraviolet rays of the sun reaching the earth's surface in larger amounts is increasing with the ozone layer becoming thinner in those parts of the world. The blue ozone layer has turned brown in some places of these areas. A group of British scientists drew the attention of the scientists throughout the world to this problem for the first time in 1985. According to them a massive hole in the ozone layer in the sky of Antarctica is being observed since 1979 during each spring in Antarctica.

It has since been unveiled that the ozone layer is being damaged not only in Antarctica, but also in other parts of the world. As the ozone layer over Antarctica is most severely damaged due to its special climatic situation, scientists apprehend that the danger of the ozone layer depletion may spread quickly in the adjoining regions. Among such regions are large parts of Australia, New zealand, Argentina, Chile, Brazil, Uruguay etc. Although the danger is more concentrated in the south polar regions, the north polar regions are not free from this danger, this was revealed though a survey conducted in the Greenland in the winter in 1988.

A startling disclosure was made by the NIMBUS -7 satellite of NASA (the National Aeronautics and Space Administration, U.S.A.) in September, 1992 : the hole over Antarctica had grown to a size three times bigger than the area of U.S.A. and stood at about 23 million sq km and was 80% thinner than usual. Such a situation would permit much greater penetration of the dangerous ultraviolet B (UV - B) radiation in sunrays that is damaging to virtually all forms of life. UV-B effect may extend upto a depth of 25 m and adversely affect growth of phyto- and zooplankton in the seas, oceans and other water bodies.

6.4.2. Possible effects of thinning of ozone layer

With thinning of the stratospheric ozone layer the ultraviolet rays of the sun will reach the earth's surface in a larger proportion causing damaging effects on public health and on the plants and animals. This may cause cataract of the eyes, allergy, different skin diseases, and even skin cancer especially in people with light skin colour. Reduction in crop production and quality of product may occur; crop plants may become susceptible towards pests and diseases. The ultraviolet rays may have damaging effects on the marine ecosystem and fish population may be decreased, because of adverse effects on the food chain especially on the phytoplanktons. As a result the entire marine food-cycle may be disrupted. The greatest danger may be there on the flora and fauna of Antarctica—the krill, whale, seal and other mammals of Antarctica may be very badly affected.

Already the number of persons attacked with skin cancer is gradually increasing throughout the world, specially in the countries adjacent to Antarctica and skin cancer is noticed particularly among those persons who have to spend a major part of the day in direct sunrays under an open sky. It has been apprehended that the number of persons attacked with skin cancer would increase at least by 4-5 per cent if the amount of ozone in the ozone layer reduces merely by one per cent. The persons who live in areas directly below the depleted ozone layers are more likely to be attacked with skin cancers. People of Australia, NewZealand, Argentina, Chile etc. may be most badly affected, because these countries are with in the ambit of the ozone-hole of Antarctica during its spring. More and more people of Australia and the U.S.A. are being attacked with melanoma, a very dangerous type of skin cancer. In other places of the world also, the number of persons being attacked with melanoma is increasing at a rate of 3 to 7 per cent. According to the Environment Protection Agency (E.P.A.), U.S.A., this is happening due to the ozone layer becoming thinner and the ultraviolet rays falling on the earth in a larger proportion. The damaging effect of ultraviolet rays on the body's immunity system and consequent loss of resistance to diseases may result in the spread of communicative diseases in particular. Medicines may not work well against diptheria, tuberculosis etc. and death of the persons attacked with AIDS may be greatly hastened.

The ultraviolet rays particularly the more penetrating UV-B rays may have other harmful effects also. Articles made of plastic, PVC pipe lines etc. may become brittle and useless. Oxygen of the air in contact with earth's surface may be partially converted to ozone and this ozone (tropospheric ozone) is a strong air-pollutant and through formation of smog would cause damage to the plants and crops also.

6.4.3. Causes of depletion of ozone layer

At first, it was thought that the flying of supersonic jet planes through the upper sky was responsible for the decomposition of ozone of the ozone layer, but now most scientists are of the opinion that it is the chlorofluorocarbon compounds (abbreviated as CFC) which are mainly responsible for such decomposition of ozone of the ozone layer. The factors responsible for the formation of ozone hole in the Antarcica are complex and scientists believe that the special climatic situation of Antarctica, namely, formation of polar stratospheric clouds, lower concentration of the oxides of nitrogen in the stratospheric air and high concentration of active chlorine formed from chlorofluorocarbons are collectively responsible for the phenomenon.

During March to August, the months preceding the spring (September-October) in Antarctica, the temperature of the atmosphere falls to — 90°C or less, as a result the water vapour of the air condenses and forms the polar stratospheric cloud. A situation is created that is favourable for the various chemical compounds suspended in the air to react chemically among themselves in contact with the ice crystals formed in such a cloud. The oxides of nitrogen become converted to concentrated nitric acid, as a result the chlorine produced from the chlorofluorocarbons cannot react with the oxides of nitrogen and cannot be rendered inactive (chlorine does not react with nitric acid). During this period the sky of Antarctica does not show up the sun and darkness prevails in the landscape of the icy land. But with the appearance of spring, when the sun appears on the sky and the atmosphere becomes exposed to the sun rays, the chlorine becomes highly active and starts the process of decomposition of ozone of the ozone layer. The process continues as a chain reaction for a period of 5-6 weeks. In the reaction, ozone decomposes to oxygen, chlorine acting as a catalyst remains almost unconverted. It has been estimated that a single chlorine atom can destroy as many as 1,00,000 (one lakh) molecules of ozone. Chloroflurocarbons are quite stable, non-poisonous and noncombustible (when present in the tropospheric air). The commercial name of the first of this series of compounds manufactured is Freon and it is also known as CFC-12 (first manufactured by Du Pont Company in 1931). The compound is used as a refrigerant in cold storages, refrigerators and in refrigeration within motor cars, it is also used as an insulator in telephones, plastic articles etc. Besides CFC-12, many such compounds were manufactured later on, such as CFC-11, CFC-13 etc. CFC-11 and CFC-12 are widely used as propellants for spraying hair-spray, various cosmetics, pesticides, fragrant substances etc. CFC-113 is used as a solvent for removing dust from electronic equipment.

The U.S.A. is the user of about 29% of the total amount of CFC compounds consumed throughout the world. Next major consumers of such compounds are the industrially developed countries of Europe, Canada, Japan, and Australia. China and India jointly consume about 2%, while the other countries of the third world consume combinedly about 14% of such compounds used in the entire world.

CFC compounds slowly rise higher from the ambient air and may reach the stratosphere within 6 to 8 years. These compounds may exist for more than 100 years in the stratosphere. Due to collision with the ultraviolet rays of the sun, these compounds slowly breakdown to liberate chlorine atoms which start the splitting of ozone. Emission of CFC-11 and CFC-12 in atmosphere is increasing at an average rate of 5 per cent per year.

CFC compounds are actually included in the general group of compounds, known as 'halons'. The compounds of this class containing bromine such as halon-1211 and halon-1301 are widely used as fire extinguishers specially in computer rooms, telephone exchanges, vaults in the banks etc. These compounds emit bromine after moving up in the stratosphere, the ozone depleting power of bromine is much higher than that of chlorine.

Besides chloroflurocarbons and bromoflurocarbons, methyl chloroform and carbon tetrachloride which are widely used as organic solvents take active part in the break down of stratospheric ozone.

6.4.4. Possible means of counteracting ozone depleting substances (ODS)

The efforts which are being made in this regard may be classified into three types.

(a) taking measures for stopping or controlling emission of these substances in air, making arrangement for recycling the used substances.

(b) finding alternatives to the damaging substances so that the alternatives would be destroyed before reaching the ozone layer or would not react with ozone even if they reach the ozone layer.

(c) gradually reducing and ultimately totally stopping the production and use of the ozone depleting substances.

The recovery of those CFC compounds which are used as solvents is not much difficult. Some companies in Germany, U.S.A. and Japan have been able to recover 70-95% of the used CFC compounds. In the United Kingdom, using developed technology it has been possible to recover 80-90% of the CFC compounds used for the production of flexible foams. The emission in air of CFC compounds used for refrigeration in the refrigerators, cold storage or in the motor vehicles, may be largely controlled through proper planning, maintenance, and taking measures to stop leakage. In a few cities of West Germany, persons collect unusable or obsolete refrigerators moving from door to door and then the CFC compounds are recovered from such refrigerators.

But the arrangement for recovery of CFC compounds is this way in a short-term measure only and 100% recovery is not possible in any way. Even traces of CFC are capable of causing severe damage to the ozone layer. Hence as a long-term measure, we should think of production and use of alternatives to the ozone depleting substances.

Two companies Du Pont and I.C.I. are trying to produce and use hydrofluorocarbon compounds (HFCs) free from chlorine as alternatives to CFC-12. Some other companies have also produced similar type of compounds. The ozone-destroying power of such compounds is only 5% of that of the CFCs, but the cost of their production is 3-5 times the cost of production of CFCs.

In many countries, helium and ammonia are used as a refrigerant in refrigerators and motor cars instead of CFCs (e.g. helium in Sanghai and ammonia in Japan). It is not much difficult to reduce emission of halons in air, because such compounds are used only in case of a fire.

In September 1987, an international treaty on the control of use of ozone depleting substances was signed in Montreal in Canada (known as Montreal Protocol). Twentyfour countries were signatories to the treaty, later 25 other countries signed the treaty. It was decided in the treaty that the production of CFCs would have to be reduced by 1998 to the level of 50% of the production in 1986.

Montreal protocol may be regarded as a remarkable achievement in the field of the environment programme of the United Nations (UNEP). But the environmentalists apprehend that even if properly implemented the treaty will not ensure full protection, because the ozone depleting substances which have been already emitted in the atmosphere in the meantime will go on destroying the ozone layer, the life periods of such substances being quite long. Assuming the average life period of the CFC compounds to be 100 years, scientists have estimated that even 100 years after total implementation of the Montreal protocol, 37% of the CFC compounds already emitted will remain in the ozone layer, there will remain about 13% of these compounds after 200 years and 4% after 300 years. Besides, CFCs from the store of such compounds already developed in the meantime will continue destroying the ozone-layer. Hence the environmentalists, while appreciating the decisions of the Montreal protocol, are of the opinion that the decisions taken there were not adequate. In the proclamation for conservation of the ozone layer in May, 1989 in Helsinki, the decision for total stoppage of production and use of CFCs was taken up.

For the protection of ozone layer, some programmes have been taken up at the national level in India also. But in recent times it is observed that advertisements for sale of halons as fire extinguishers are on the rise. We very often notice that those chemicals, production and use of which are banned in the developed countries, are being widely used in this country. Proper measures should be taken in this regard.

6.5. Noise pollution

Sound has provided us with the faculty of oral communication and an excellent medium for exchanging our ideas. Warble of birds, sweet sound of sitar, sweet music, recitation in a melodious voice, the words of near and dear ones all bring so much pleasure to us. If a person, who is not an asectic or one who wants total seclusion, is kept in a solitary room for quite a good number of days at a stretch, he may even turn mad. Sound is undoubtedly a valuable asset. But if this sound becomes devoid of its pleasing note or becomes very loud, continuous or repetitive in nature, it would irritate and disturb us and may even become painful to us; such a sound becomes a noise.

Noise has been defined in many ways. The sound which is without a pleasing note, undesirable, uncomfortable and irritating to the recipient, may be called noise. Noise is the wrong sound at the wrong place and at the wrong time. A particular sound which is pleasing to a particular person may be an irritating noise to another person. A particular sound again may appear to be pleasing when it is low, but it may become a noise and irritating when it is very loud.

There are quite a number of definitions of noise pollution and one such definition is as follows. Noise pollution is defined as an unwanted sound that causes discomfort, disturbance and irritation and interferes with normal verbal communication and has ill effects on mental and physical health. The extent of noise pollution generally depends on the intensity of the noise and its duration—length of time and repetitive occurrence. The noise of continuous hammering, loud sound of air-horn in motor vehicles, noise of prolonged operation of a generator or water pump, blaring loudspeakers etc. are some examples of noise pollution.

6.5.1. Different sources of noise and noise pollution

Various noise pollution due to various anthropogenic activities may be broadly classified into three types, viz. (i) traffic and transport, (ii) industries (factories), and (iii) machines, (mortar mixing, welding, reparing etc.), gadgets and activities taking place in domestic and neighbourhood areas.

6.5.1.1. Noise generated by traffic and transport

Traffic and transport may be mainly of three types (a) surface transport by road, (b) air-transport, and (c) rail transport.

Due to the ever increasing number of motor vehiches in the cities, the problem of noise pollution is becoming more and more acute particularly in the cities. Noise level and its intensity depend not only on the speed and weight of the vehicles, but also on the condition of the road, the number of vehicles passing through a particular point per hour, condition of the engines of the vehicles, nature of the fuel used etc. Generally the heavy diesel operated vehicles create noise of greater intensity. In the cities, the level of noise becomes maximum generally at the peak hours of the day when the number of the running vehicles becomes maximum. In Calcutta, the noise level near the roads leading to the office areas becomes maximum during the peak hours of going to and returning from the offices. The number of registered motor vehicles in Calcutta is about 9 lakh (0.9 million) whereas the road area in the city is only 6 per cent of the total area. Plying of such a large number of vehicles (many with ill maintained old engines) over such a limited road space is the main cause of noise pollution in the city. In the major cities, noise created due to surface transport remains almost always there throughout the day and even at night sometimes at a low level and sometimes at a high level as the major thoroughfares are seldom totally free from vehicles.

The noise arising out of air transport is not continuous, but the intensity of such a noise is much higher than that of noise generated from surface transport. The intensity of such noise becomes maximum at the time of take off and landing of aircrafts. The intensity of the noise generated by jet-planes is higher than that of other types of air-planes. In the cases of supersonic aircrafts (such as the Concorde) the intensity of the noise generated is so high that there may be damaging effects of the noise even on the buildings situated near the airport. People residing in areas near the air-ports are generally the major victims from air-transport related noise pollution.

Noise pollution resulting from rail transport is usually not very severe (except in major railway junctions), because rail transport arrangement is generally made in such a way that the transport system remains outside the residential locality. But due to the tremendous pressure of population, the residential areas are now being developed near railway stations. Hence the residents of such localities are suffering from noise pollution arising out of rail transport. Besides noise pollution the houses situated, near the railway lines may also be damaged due to vibration.

6.5.1.2. Noise arising out of industries

The noise of various machines being operated in different industries and various processes operating within these industries create the problem of noise pollution. The workers of these industries and the people of nearby areas are the victims of such pollution. Noise of almost continuously operating mechanical saw, drilling, cutting, crushing and grinding machines running at a stretch and the noise of operation of rice mills, wheat mills etc, within the locality are sources of considerable irritation and annoyance and psychologically highly disturbing.

6.5.1.3. Noise from domestic and neighbourhood soruces

The sound generated from different machines and gadgets used in our houses may create noise and noise pollution. The continuous sound from generators, water pumps, washing machine, high level noise generated due to operation of television, radio, tape-recorder, etc., the sound of vacuum cleaners, defective electric fans are all causes of noise pollution. the noise generated due to people participating in meetings, processions (including funeral procession of certain communities), the loud voice coming from loudspeakers microphones used in nearby places of worship or in social functions, the peculiar noise generated from markets, sound generated from sporadic violent activities of people in the neighbourhood etc. create noise pollution.

6.5.2. The intensity level of sound

The intensity level of sound is expressed in the unit of Bel or deciBel also written as decibel with a small 'b' (1 bel = 10 decibels). The nomenclature of this unit has been after the name of Alexander Graham Bel, the inventor of the telephone. The definition of decibel may be given mathematically as follows.

$$\text{decibel (dB)} = 10 \log_{10} \frac{\text{the intensity measured (I)}}{\text{the intensity of the reference } (I_0)}$$

where the reference sound (I_0) is the minimum sound audible to the average human ear.

As the scale is logarithmic it implies that a sound of 100 dB has 10 times as much sound energy as 90 dB.

The faintest sound audible to the human ear is taken as 1 dB on a scale ordinarily ranging from 0 to 130 dB.

The intensity level of sound generated by several sources is shown in the table below.

Table 6.1. Intensity level of sound from different sources

Sound	*Intensity level in decibel units*
Normal breathing	**10**
Whispering	**20**
Normal dialogue	**60**
Sound of an alarm-clock	**80**
Normal average sound from workshops	**80**
Heavy traffic	**90**
Rock music	**110**
Running motor-cycle	**118**
Jet-plane during take-off	**150**
Space-rocket during launching	**170**

Noise of 85 dB intensity level may start damaging our physiological processes, noise of 130—140 dB may deafen us and noise of 160 dB may instantaneously destroy our ear-drum permanently.

In the context of this discussion, the intensity levels of some common sound sources are noteworthy :

Table 6.2. Intensity level of sound from a few common sources

Noise source	*Intensity level (dB)*
Normal sound from a radio	**45**
Operating a radio at a loud voice	**70**
Sound from crackers	**90-120**
Loud voice from microphones (loudspeakers)	**100-110**
Operation of relatively large water-pumps	**90-100**

In view of the permissible limits of noise levels as specified by the Central Pollution

Control Board (CPCB) for the four zones in a city, the actual state of affairs in Calcutta may be clear from the following table :

Table 6.3. Specified safe noise levels in a city and actual noise levels in Calcutta

Particular zone	*Specified safe noise level (dB)*		*Actual noise levels (dB) in Calcutta*	
	Day	Night	Day	Night
Residential zone	55	45	79	65
Silence zone	50	40	79	65 (hospitals, educational institutions etc. upto a distance of 100m)
Commercial/Business zone	65	55	82	75
Industrial zone	75	65	78	67

It is evident from the table that excepting the industrial zone, the noise levels are much higher than the safe limits as prescribed by CPCB in all other zones. The noise-levels in the residential zone and in the silence zone are similar and the noise level in the business zone is higher than that in the industrial zone. In the silence zone use of air-horns of motor vehicles is prohibited, but the law is not given due respect by the motorists. That is why there is practically no difference in the noise levels in the silence zone and in the residential zone.

The noise levels of some of the important areas of Calcutta may be compared with the data shown in the above table so that a clear idea may be obtained regarding the state of affairs.

Table 6.4. Ambient community noise levels[a] in some locations in Calcutta city

Sl. No.	*Locations*	*Type of Area*	*Morning*	*Afternoon*	*Night*
1.	New Alipur (P Block)	Residential	70.5	64.0	63.8
2.	Jadavpur Station Road (near 8B Bus Stand)	Commercial	78.6	78.9	69.8
3.	Jodhpur Park	Residential	69.1	63.6	66.4
4.	Ballygunge (Ekdalia Park)	Residential	71.6	67.4	66.7
5.	Gariahat Market	Commercial	77.9	81.6	75.6
6.	Rashbehari More (near Lake Market)	Commercial	76.1	78.7	81.5
7.	Bhawnipore (near Post Office)	Residential	70.3	67.6	69.2
8.	Victoria Memorial (Tomb)	Recreational	68.1	66.5	69.7
9.	Park Street (Shopping Area)	Commercial	79.2	81.1	77.8
10.	Park Circus Maidan	Commercial	81.0	77.0	76.9

Sl. No.	Locations	Type of Area	Morning	Afternoon	Night
11.	Nilratan Sirkar Medical College & Hospital (Emergency Block)	Silence Zone	64.8	68.3	66.3
12.	Sealdah Station Area	Commercial	69.7	76.5	71.0
13.	S. N. Banerjee Road (Taltola Area)	Commercial	77.3	77.6	71.6
14.	Esplanade (Bus Terminus)	Commercial	78.4	77.3	74.2
15.	Calcutta High Court (Main Gate)	Silence Zone	67.0	70.3	64.6
16.	B. B. D. Bag (Shopping Area)	Commercial	85.6	73.3	74.5
17.	Burrabazar (Shopping Area)	Commercial	75.4	76.8	76.5
18.	Calcutta University (College Street Campus)	Silence Zone	64.9	65.2	52.2
19.	Girish Park (Shopping Area)	Commercial	78.7	76.9	78.4
20.	Shyambazar	Commercial	80.3	78.1	76.5
21.	Dunlop Bridge	Industrial	82.8	81.1	73.3
22.	Ultadanga-Muraripukur	Industrial	84.6	72.8	77.0
23.	Salt Lake (AC Block)	Residential	72.2	70.6	60.1
24.	Rajabazar (Inside Colony)	Residential	71.2	77.9	63.0

(a)Equivalent continuous noise level for 30 min in A weighting.

Morning = 8.00 A.M. - 11.00 P.M.

Afternoon = 2.00 P.M. - 5.00 P.M.

Night = 9.00 P.M. - 12.00 P.M.

[Source : West Bengal Pollution Control Board (Sound recorded in 1995)]

6.5.3 The harmful effects of noise pollution

Noise pollution may have harmful effects on both our body and mind i.e. such effects may be physiological and psychological. Generally, the extent of damage depends on the noise level and its duration. The safe intensity level of sound as prescribed by the World Health Organization is 45 dB. Even if a sound of 45 dB is continuously experienced by our ears, we may feel irritated, our sleeping may be disturbed. A noise of 80 dB may cause anger while a noise of 85 dB starts damaging our ears. A continuous noise of 88 dB may cause a beginning of hearing loss, a noise of 110 dB causes discomfort, noise of 135 dB is painful to us, while a noise of 150–160 dB may cause permanent deafness. The permissible time-period per day for remaining within different noise levels without having injurious effects on health are mentioned in the following table :

Table 6.5. Permissible durations for different noise levels

Noise level (decibel units)	*Maximum duration permissible daily*
90	**8 hours**
95	**4 hours**
100	**2 hours**
105	**1 hour**
110	**1/2 hour (30 min)**
115	**1/4 hour (15 min)**

We hear a sound through our ears, as such, loud noise directly causes harm to our hearing power. If someone remains for a prolonged period within a high noise level of 130 dB or higher they may have a feeling of ringing within the ears and in some cases the same may turn to be a permanent disease that is known as tinnitis. There is practically no treatment for this disease and the pain from such disease may sometimes become intolerable. Some observations from various research on noise are mentionworthy, e.g. the hearing capacity of rural people living in a calm and quiet environment is generally much higher than that of urban people living in a much more noisy environment. Through conduct of a comparative survey among the people of the U.S.A. having a noisy environment and the people of Sudan having a very calm environment, it has been observed that while an American loses, on an average, 40% of his hearing ability at the age of 65, a Sudanese even at his age of 70 years has his hearing ability almost unchanged.

In a survey in the areas near Dum Dum Airport (Netaji Subhas International Airport, Calcutta) it has been observed that people residing in the area generally have low hearing power and about 16% of such people have the problem of short hearing. In an experiment conducted by the audiologists in the West, it was found that due to exposure to a recorded rock-music for a continuous period of 88 hours, the cells of the vital tissues of the ear of the experimented guinea pigs were totally damaged. From surveys conducted on the workers belonging to the same workshop it has been found that those workers working in the high noise-level zone in the workshop generally have less hearing ability than those working in the lower noise level zone.

Besides reduction or loss of hearing capacity, noise pollution, may have other adverse physiological and psychological effects. Noise pollution may cause irritation and mental depression or anger, we may lose our concentration, school-going boys and girls in particular, may become unmindful in their classes. Those persons who have to work within an environment of very high noise level, such as drivers of heavy-duty trucks and lorries, workers in some industries, are generally a bit more aggressive and rude in nature. They behave so probably because they are victims of noise pollution.

As a result of noise pollution, persons may suffer from tension, headache, migraine, they may be attacked with neurological diseases, their blood pressure and blood sugar level may become high and efficiency may go down appreciabely. A continuous noise of high level may be detrimental to the cardiac patients. Noise pollution may cause mental anxiety that is supposed to be a causative factor of peptic ulcer. Pregnant women exposed to a high noise level for a long period, may give birth to low-weight or physically or mentally retarded children. A research conducted in the U.S.A., has shown that about 2% of the total population suffer from psychological diseases, but among the persons living in regions where population density is high and the environment is much noisy, about 10% of the population are victims of mental diseases.

6.5.4. Measures to control noise pollution

It is to be mentioned clearly that noise pollution is closely associated with the progress of modern civilization and therefore it cannot be totally stopped. However, through adoption of suitable scientific measures, the intensity levels of the noise (and consequent noise pollution) may be substantially controlled.

For the control of noise pollution, generally three types of measures may be taken.

(i) Taking up some steps at the noise source itself aimed towards reduction of the intensity level of the noise.

(ii) Noise-absorptive measures may be taken in between the source of the noise and the recipient of the noise.

(iii) Adoption of some protective measures by the recipient so that the intensity level of the noise is reduced to some extent before actually entering into the inner part of the ear of the recipient.

Besides such methods, through adoption of appropriate town planning, framing and implementing proper laws in this regard, taking up some administrative measures and through development of a wide awareness among the public about noise pollution, the level of the pollution may be controlled to a great extent.

(i) The level of noise generated from generators, water pumps etc. may be reduced somewhat by proper installation such as placing them on heavy pads made of sound-absorbing materials and arranging for a sound-proof enclosure for them. Noise level may also be reduced to some extent by proper maintenance. By reducing the intensity of sound of loud speakers, by playing the casette recorder in casette shops or houses at a low sound level, by stopping blowing of air-horns in motor vehicles, through proper maintenance of machines in the factories and industries, and through application of appropirate acoustics technology for reduction of noise level, noise pollution may be controlled to a considerable extent.

In our residential houses (or in other houses also) we should prefer to use furniture made of sound-absorbing materials. Residential houses and flats should preferably be located away from a highway or a broad street through which heavy trucks and vehicles ply almost continuously. If the windows of a house be situated in the direction of a noise-prone road, it is proper to use heavy curtains. If there are generators, water pumps etc. in our dwelling houses, we should plan to install these machines as far away as possible from our bedrooms or from the studyroom of the children in particular. Use of radio, television, tape-recorder etc. should be kept to the possible minimum and that also at a low sound volume.

(ii) The second type of arrangement which can be made in this respect is to take some protective measures on the part of the recipient of the noise. These devices reduce the level of noise before the sound enters into the inner parts of the ear of the listner. If the noise level is very high, ear-plug and ear-muff may be used together. In case of non-availability of such equipments, persons who have to work in a noisy environment may be advised to cover the ears with cotton soaked in such an oil (to make the cotton more impermeable) which is not injurious to our health.

With a view to controlling noise pollution arising out of transpont and industries, it is necessary to develop proper technology or else to import available technology from abroad. For example, in the United Kingdom, in order to reduce noise level in the motor vehicles, clothed air-compressors are used in the engines of the vehicles. It has been observed that as a result of this arrangement, it has been possible to reduce a noise level of 96 dB to about 69 dB. In our country also, we may take such measures to reduce the level of noise arising out of motor vehicles. We should try to apply suitable technology to reduce noise level in the tube rail, circular rail and in the tram cars also. As a continuous and loud sound generally causes more noise pollution, it is possible to reduce to some extent of noise pollution in some cases by making the sound discontinuous. In the trains running through populated areas instead of the present whistling at a stretch system, an effective discontinuous warning system may be adopted.

(iii) By taking different measures in between the source and the recipient it is possible to reduce the intensity of a sound to some extent. For example, if the sound is generated from an industry, the intensity of the sound may be reduced by making an enclosure of densly planted selected trees and creepers around the factory. By placing or erecting in a planned manner some boards, walls etc. made of sound-absorbent materials in the track of the sound, it is possible to reduce the noise level. The hoardings used for advertisement purposes which are used in a large number near city streets mainly, may be made of sound-absorbent materials so that these may be used effectively for absorbing noise generated from motor vehicles and road traffic. In the auditoriums,by using a special type of cément (sorel cement) in the construction of its walls, the noise level may be reduced by reducing reflection of the sound from the walls. An enclosure of trees should also be made surrounding all hospitals and schools etc.

(iv) Through a proper town planning, by locating and establishing some sources of loud noise far away from the residential areas (and if possible keeping in mind the predominant prevailing wind direction) by proper implementation of the planning for developing the residential zone and the silence zone away from the commercial and industrial zones, by proper maintenance of the roads of the town, it is possible to control noise pollution to considerable extent. For example, airport should be located at a safe distance from the habitation, Railway station and the rail transport system should remain somewhat away from the dwelling areas.

Similarly, through framing of suitable laws and by strict application of the same, noise pollution level can be somewhat reduced — it has been already experienced by us. Prohibition regarding explosion of crackers producing loud noise and operation of loud speakers in the festival pandals during a fixed period of the day, imposing restriction on maintenance of noise level at 65 dB, have brought considerable relief to the citizens in the recent times. To have a desired result in this respect, a wide mass awareness is to be developed along with the restrictive measures on the part of administration. The educational institutions have an important role in the matter.

There are specific laws in some countries (such as Canada) regarding use of domestic sound-producing devices. Such laws may be framed and implemented in our cities also if situation so demands.

A fact should be mentioned here. Due to a tremendous pressure of population, a large number of villages in India have practically been converted to semi-towns. The associates, both good and bad, of modern urban civilization are there in such villages also. These villages are, therefore, not free from the problem of noise pollution. In the cities, the municipalities and the citizens should think over the way out of the problem, similarly the *Panchayet* and the village people should not neglect this problem.

Taking administrative measures according to a comprehensive scientific planning, framing of appropriate laws and strict application of such laws, development of a wide mass awareness and conduct of a constructive and continuous mass-movement and through a combination of all these, noise pollution can be greatly controlled.

6.6. Odorous pollutants

In our daily life we have to come in contact with various aromatic (odorous) substances. Some of these odorous substances appear to be pleasant to us giving a relief to our body and mind, some other such substances appear to be much impleasant to us, bad smell coming from these appear to be intolerable to us. But be it good or bad odour, such a substance or particulates or gaseous substances coming out of such a substance may pollute air and breathing in such air may have ill effects on our body and mind. Air pollution due to odorous substances may be called odour pollution. Perception of odour is, however, subjective. What is a very bad odour to one person, may not appear that much bad to another person. The intensity of odour as perceived by a person may depend on the age and sex of the person. Even what is a bad odour to one may appear to be a good one to another.

6.6.1. Sources of odour pollution

Some sources of bad odour experienced by us in our daily life may be recollected. The major sources are

(i) Garbage : Due to putrefaction of heaped garbage on roadside vats or any other place we have to experience foul odours. Various substances are present in a garbage such as metallic substances, cut pieces of vegetables, paper pieces, glass bottles, coconut shells etc. A portion of the heaped garbage remains always there in the vat or elsewhere because of incomplete removal of old garbage and new wastes deposited on that. Due to fermentation of organic substances present in the garbage some volatile chemical compounds are produced and they mix in the air, resulting in the emanation of a foul odour to the local air. Inhalation of such air does not only cause irritation and nausea to us, but may cause serious damaging effects also on our health. In Calcutta, about 3100 tonnes of solid wastes are deposited everyday on an average, about 10 percent of which may remain there throughout the day. Due to putrefaction of such wastes an unpleasant situation is created in the areas adjoining the bins or vats or open dumps.

(ii) Public urinals, toilets etc. : In certain areas ammonia gas and other foul-smelling gases coming out of the public urinals, latrines etc. or from such largely used places belonging to hospitals, large office buildings, educational institutions etc. may cause pollution to some extent. The pungent smell of ammonia in particular is unhygienic and may be irritating to us.

(iii) Poultry, piggery, cattle-shed etc. : Foul odour comes out of such places also. Methane, ammonia and other gases produced due to fermentation of cow dung in cattle shed pollute air, hydrogen sulphide gas formed due to some eggs being rotten in the poultries is a bad odoured and poisonous gas. Methane, ammonia and hydrogen sulphide gases may also come out from unauthorized pig-keeping in some areas.

(iv) Morgue : As because hospitals and morgues are mostly situated in populated areas, foul odour, coming out of poorly preserved dead bodies and post-mortem dissection of the dead bodies kept there, spreads in the area. Such foul odour has a very bad effect on our body and mind. Such a bad odour may also be experienced to some extent in areas adjacent to a crematorium. Besides, due to putrefaction of the dead bodies of animals especially at the time of natural calamities, the air becomes highly polluted due to foul odour with consequent effect on public health. A recent example of an all-pervading odour pollution has been the super-cyclone in Orissa due to nondisposal carcasses following the devastating cyclone.

(v) Man-holes, unused wells, drains etc. : Foul odour comes from a man-hole when its lid is open or it comes from very old unused draw-wells and from drains which are not cleaned regularly. Sometimes persons working within such man-holes, draw-wells, wells etc. may even lose thier lives because of serious gas poisoning. The experience of bad odour arising from the drains or unused canals because of fermentation of various organic wastes, mud and slash is a common one. The choked or nearly choked canals in Calcutta, such as in Beliaghata, Kestopur, Bagjola, Tollynallah are in a very bad condition due to lack of porper cleaning and dredging from time to time. Besides creating various environmental hazards, these may be regarded as permanent sources of foul odour.

(vi) Tanneries : If the tanneries are located near residential areas not only the bad odour coming from these may irritate us, but some products used in the tanneries or coming out as waste products may also be detrimental to public health. Although the tannery effluents are mainly water pollutants, the odour may spread in the surrounding air making it polluted. Some heavy metals (such as lead, chromium etc.), leather dust, some organic chemicals (e.g. tannic acid) are present in the pollutants. We have a bitter experience with the bad odour and the pollutants coming out of the tanneries situated in the Tiljala area of Calcutta (since shifted under court order).

6.6.2. Other odorous industrial pollutants

Different types of odorous pollutants emitted from various industries also may mix with air and render it polluted. Although such odorous pollutants contain mainly some volatile and unsaturated organic compounds, there may be some inorganic substances in some cases. Some industries along with the odorous pollutants emitted from them are given below :

Industry	Odorous pollutants
(i) Fertilizers	Ammonia, bone dust etc
(ii) Petroleum	Sulphur dioxide and sulphurous compounds, cresols etc.
(iii) Paper	Sulphurous compounds
(iv) Coke-ovens	Ammoniacal and sulphurous compounds, phenolic compounds
(v) Soap	Animal fats and fatty acid decomposition products
(vi) Food-processing	Dairy wastes, stale meat products, fishy smell

In order to make food more flavoured and attractive, some chemicals are sometimes mixed with such food. In some cases, the added chemicals may be detrimental to public health. Monosodium glutamate (MSG), a chemical compound of this type, is frequently added to processed food in some restaurants, its odour is somewhat similar to that of tomato. It is alleged that taking food mixed with this compound in such restaurants would produce adverse effects, such as swelling of lip, irritation of eyes and vomitting tendency. However, the matter needs further verification. According to some, it is not sodium glutamate but a special type of sauce used with food in some restaurants that is actually responsible for creating such sickness. A similar chemical used in some restaurants is monopotassium glutamate which is used as a flavourant in the processed meat and in the tinned food. These may not be very safe for public health.

In some confectioneries, with a view to making the product more attractive, the various sweets, not only artificial colouring substances, but some flavouring agents are also added.

Sometimes these artificial colouring flavouring agents cause nausea, allergy, stomach-ache to some persons taking these products.

Jam, jelly, pickles etc. are also flavoured artificially sometimes with chemicals which may not be good for health. Sometimes, some drinks are also artificially flavoured. In those places where there is a general attitude among people for taking over-spiced and artificially flavoured food, there are often allegations from persons of stomach-ache, nausea etc. following consumption of such food. Artificial flavouring agents used as food-additives in such cases may be responsible for the trouble reported.

Some fragrant organic liquids which may be used as solvents or otherwise in nail polish, lipstick or in various perfumes, and also in the computer or in semiconductor industries may have ill effects on the public health. Some substances of this type and their possible harmful effects on public health are mentioned below.

Acetone : In contact with its vapour in medium or high levels, we may experience irritation in our eyes, nose and throat, we may have confusion and a loss of memory. In contact with very high levels of its vapours, we may be senseless, mucous membrane within our mouth may be damaged. Kidney, liver and the nerves may be permanently injured in contact with acetone vapours for a prolonged period.

Benzene : It may damage bone-marrow as a result of which production of red blood corpuscles may be reduced resulting in anaemia, leucemia, etc. reproduction capacity may be reduced, immune system is affected. Benzene is a carcinogen.

Methyl chloroform : This causes headache, irritation to eyes, nose and throat, brings in the possibility of cardiac diseases.

Toluene : Due to exposure to its vapours for a long period we may feel tired or weak with a feeling of nausea, we may lose hearing capacity and suffer loss of memory. Inhalation of its vapours at high level for even a short period may damage our brain, we may have a problem of vision and hearing and a feeling of an imbalance in our body. It causes neurological problems, impedes grwoth of the children, and is carcinogenic.

6.6.3. Control measures

It is possible to control the problems of odour pollution through a proper environment management, at least to a considerable extent.

Proper measures for removal of solid waste must be taken in order to get rid of the problem of odour pollution resulting out of garbage. As a portion of the deposited solid waste remains in the vats or elsewhere in our cities for a prolonged period, the municipal authorities may be urged to arrange for collection of the waste at least twice a day. The vats should not be situated in populated areas. In the rural areas also, the wastes should be dumped at a place far from the locality and preferably within a reservoir, the base and the four walls of which should be plastered with cement or concrete, compost manure may be prepared from such wastes. The

Panchayats may adopt suitable measures in this respect. The municipal solid wastes may also be used for production of manures, biogas and power and such wastes may be regarded as resources rather than mere hazardous pollutants.

The cattle-sheds, poultries, piggeries etc. should be situated outside the residential localities and there should be a scientific management system for removal of wastes from such places. Similarly the wastes from public toilets, urinals etc. may be utilized for heating gas generation.

Morgues should not be located in populated areas and if there is no other alternative in this respect, measures must be taken so that foul odour from the morgues would not spread in the locality. An enclosure of selected perennial trees, particularly those containing fragrant flowers, surrounding such places may somewhat reduce spreading of foul odour.

The functionaries of the municipalities (and the citizens also) should keep a continuous and sharp watch so that the lids of the man-holes in the streets are not kept open unduly or removed. The old wells, draw-wells etc. should be cleaned from time to time so that the possibility of poisonous gases coming out of these sources may be somewhat reduced, when necessary, water of such sources may also be used for cleaning programmes.

The tanneries or other industries acting as sources of odour-pollution should be removed from populated areas and proper pollution-control measures should be taken in such industries. Proper technology should be used to utilize otherwise the waste products from these industries. The department of science and technology of the government should try to develop apropriate technology in this regard.

It is desirable to avoid use of cheap perfumes, nail polish etc. The health department of the government or the municipality should have a strict and regular vigilance to examine whether the flavouring agents (or colouring agents) used as addenda to food, sweets, drinks etc. are permissible and safe for public health. It is wise and desirable for us to refrain from taking artificially flavoured food, drinks etc. A wide awareness among the public is to be developed in these regards.

A method for controlling bad odours is to use deodourizers. Such deodourizers may have good smell which suppresses the obnoxious odour and spreads its own odour, some deodourizers may destroy the bad odours. In the toilets deodourizers such as odonil are often used. Bacteria, fungi or molds that create odours can be destroyed by disinfectants such as formaldehyde. In factories, sometimes it is possible to remove foul odours by adding some other odorous substances so that the combined smell of both the substances may be pleasant, this method may be termed reodourization.

CHAPTER VII

ENERGY SOURCES

7.1. Sun as the ultimate source of energy

The sun is the source of almost all kinds of energy on earth, either directly or indirectly. Fossil fuels (coal, oil and gas) are the transformed forms of plants (and animals) which once lived on the earth and grew capturing the energy of the sun. Biomass is a product of photosynthesis where the sun has the major role. Hydro-electricity depends upon the water cycle which again is dependent on solar radiation. Similarly, wind energy, tidal power, wave power all, in some way or other, depend on the sun.

The sun is an extremely hot mass of gas, where continuous thermo-nuclear reaction is taking place producing enormous quantities of heat and light. The sun radiates energy in the form of heat and light in all directions. Only a very small part of this energy is intercepted by our planet earth. Outside the earth's atmosphere the average intensity of solar energy is 1.2 kilowatt per square metre (1.2 KW/m^2). When this solar radiation passes through the atmosphere, a portion of solar energy is absorbed by the atmospheric gases and particles. The net amount of solar energy that reaches on the earth's surface is about 0.9 KW/m^2.

The radiations that reach the earth's upper atmosphere are : (wave lengths in nanometres shown in parentheses) : (i) ultraviolet radiation (less than 400 nm), (ii) visible radiation (between 400 and 750 nm), and (iii) infra-red radiation (from 750 to 2500 nm).

Ultraviolet radiation is harmful to the flora and fauna. But fortunately ozone layer on the top of our atmosphere (stratosphere) absorbs the major portion of ultraviolet radiation and a very small part of this radiation reaches the earth's surface.

The major part of the solar radiation is occupied by visible light and heat wave, both of which contribute to our energy system.

Photosynthesis : The visible part of the solar radiation is continuously performing a very important service to the living world. This service is called photosynthesis. During this process the plant prepares its own primary food taking carbon dioxide from the air and water from the soil with the help of chlorophyll present in the leaves of green plants. Sunlight acts as the source of energy required in this process :

$$\text{Carbon dioxide} + \text{Water} \xrightarrow[\text{Chlorophyll}]{\text{Sunlight}} \text{Carbohydrate} + \text{Oxygen}$$

In this reaction carbon dioxide is absorbed from the atmosphere and assimilated into carbohydrates and free oxygen (obtained from breakdown of water) is released into the atmosphere.

Evaporation : The sun is often described as a prepetual worker. We have seen that it performs photosynthesis. Also the thermal part of the solar radiation — the infra-red radiation causes evaporation from the oceans and other water bodies on the earth. The result is atmospheric water vapour (humidity), cloud, rain and snow which operate the water cycle. These are very important atmospheric phenomena without which life on earth would not survive.

7.2. Energy and society

Energy is the prime mover of the society. Without energy the human society cannot move a step forward. In the early days of civilization the humans had at their disposal only muscle power in the form of human energy and animal energy to perform the desired work. Of course, they had the blessings of the sun during the day time in the form of light and heat. That is why all the earliest civilizations on the earth be it ***Indus, Maya, Greek, Egyptian, Inka*** or ***Babylonian,*** did worship the sun as God.

When man could produce fire, that was indeed a great day for human civilization. Wood and other bio-masses like dried leaves and twigs became their source of heat and light energy, which they could get even in the absence of sun.

At this point of time man had at their disposal the following sources of energy : (i) muscle power, (ii) sun power and (iii) bio-mass power.

This kind of energy utilization continued for a very long time and the human society adopted "fuel" in the form of wood and other bio-masses. Afterwards, in some parts of the world man designed the "Wind Mill" to utilize wind power for mechanical work.

Probably, in the mid-eighteenth century, human society started using coal, a naturally occurring mineral composed of carbon, as the source of energy. Gradually, coal became the major commercial fuel. Coal is available in four different forms in terms of its carbon content : (i) anthracite, (ii) bituminous, (iii) lignite and (iv) peat.

Anthracite coal has the maximum carbon content and minimum impurities. It is mostly used for metallurgical purposes. Bituminous coal is used as a fuel for production of heat, but it contains elements like magnesium, sulphur, nitrogen etc. as impurities. Lignite and peat are very low grade coal and they contain large amounts of impurities and clay.

The calorific value of a sample of coal is its heat producing capacity. This value depends upon the carbon content of the sample. Therefore, anthracite coal has the highest calorific value and bituminous coal is the next in line.

Our major interest as fuel is the bituminous coal. When this coal is burnt, beside producing heat, it produces carbon dioxide, sulphur dioxide, nitrous oxide and ashes.

In the late eighteenth century, steam engine was invented and that was the beginning of 'Industrial Revolution' in Britain. In 1799 Alessandro Volta invented the battery, the first source of current electricity. In the 1820s Michael Faraday demonstrated a device using electro-magnetic induction to produce electricity out of mechanical rotation which he called "Dynamo". By the middle of the nineteenth century electrical power production using the heat of steam was possible. This was the beginning of "Thermal Power" production.

During this period, "Internal Combustion Engine" was invented and petroleum became an important fuel to produce motive power. Also 'Hydro-power' was harnessed to produce 'Hydro-Electricity' during this period. Therefore, at the beginning of twentieth century the list of energy sources was enlarged to (i) muscle power, (ii) sun power, (iii) bio-mass power, (iv) wind power, (v) hydro-power, (vi) coal, (vii) petroleum and natural gas, and (viii) electricity.

During World War II (1938-45) nuclear science was developed to a great height and the destructive power of the atomic energy was revealed in 1945 by the shocking and inhuman dropping of two atomic bombs on Hiroshima and Nagasaki in Japan. This gave us clue to another source of energy namely, "Nuclear Power". Since 1950, a large number of 'Nuclear Power Stations' have been established in different countries supplying substantial part of their requirement of electricity.

After 1970s, it was realized that the growing energy and power requirement of the human society cannot be met by the conventional sources of energy without hampering the quality of the environment any more. Therefore, for conservation of the environment and sustainable development search for alternative renewable and non-polluting sources of energy began. At the end of twentieth century, some hitherto untapped sources have been identified for future utilization, which include (i) solar thermal energy, (ii) solar photovoltaic energy, (iii) wind electricity, (iv) tidal power, (v) mini (or micro) hydel power, (vi) geo-thermal energy, (vii) wave power, (viii) magneto-hydro-dynamic (MHD) power, (ix) ocean thermal energy conversion (OTEC) power, and (x) nuclear fusion energy.

Of these, the last three are still in the research and development (R & D) stage.

7.2.1. Energy for development

Energy is one of the major agents of economic development of the society. The two principal forms of energy needed for economic activities are heat and electricity. Production of heat needs fuel and production of electricity needs heat.

Although this is the conventional route, there are many alternative routes of production of electricity. We know that industry and agriculture, the two pillars of economic development, require energy in various forms. Agriculture needs electricity for pumping of water and for the production of fertilizers, pesticides etc.

Industry needs electricity for lighting and also for running all machineries. Electricity is considered as the most refined and convenient form of energy. Once it is produced, it is pollution-free and is conveniently transported from one place to another through overhead wires. It can easily be transformed into heat, light, and linear and rotational movements. The present society cannot survive without heat and electricity.

7.3. Conventional sources of energy

In the previous two sections we have mentioned about the different sources of energy and their pollution potential.

If we examine the various conventional sources of energy which dominated the world market in specific periods in the past the following pattern emerges :

Period	**Fuel**
1850 - 1900 A.D.	Wood
1900 - 1950 A.D.	Coal
1950 - 2000 A.D.	Oil

Although wood is still the major fuel of the rural masses, for bulk power supply it is no longer used. To protect the environment from degradation, afforestation is being encouraged and wanton cutting of old established trees for fuel wood has been stopped through legislation.

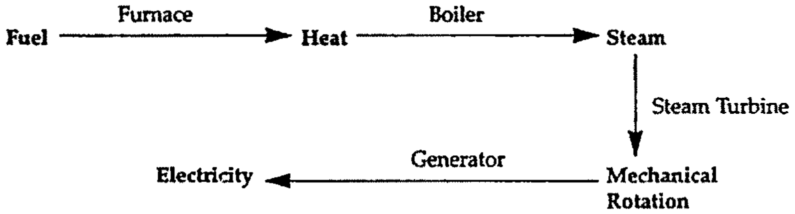
Electricity has become the symbol of progress. It can be produced in bulk quantities and can be transmitted over a long distances through "High Tension" (HT) transmission lines. We have already mastered the technology of converting electricity from high voltage to low voltage and high current to low current and *vice-versa*. We can also control the phase and frequency of electricity. We know the measurement and metering techniques of electricity. Therefore, electricity has emerged as the most conventional form of commercial energy.

The conventional routes of production of electricity are : **(i)** thermal route, **(ii)** hydel route, and **(iii)** nuclear route.

7.3.1. Thermal power

Thermal electricity generation contributes to over 72% percent of India's power supply amounting to 65000 MW out of the total installed capacity of 90,000 MW.

In a thermal power station electricity is generated by burning coal in a furnace. In the boiler, this heat is utilized to produce steam at high temperature and pressure. This steam is utilized to run the steam turbine which in turn is coupled with the generator producing electricity.



Thermal power production causes intense air pollution. Singrauli and Rihand in U.P., Talcher in Orissa, Ramagundam in A.P., Vindhyachal in M.P. and Farakka in West Bengal are some of the major thermal power stations of the National Thermal Power Corporation (NTPC) of India. Kolaghat Thermal Power Station (KTPS), Bandel Thermal Power Station (BTPS) and Titagarh Thermal Power Station are examples of state-level thermal power stations in West Bengal.

7.3.1.1. Air pollution in thermal energy production

As has been mentioned earlier, present day conventional energy production system including thermal electricity production depends mainly on fossil fuels (coal, oil and natural gas). These commercial fuels cause air pollution in the form of (i) suspended particulate matters (SPM), (ii) sulphur dioxide (SO_2), (iii) carbon monoxide (CO), (iv) nitrogen oxides (NO_x), (v) lead oxide (PbO) etc. It is estimated that 60-70 million tonnes of coal ash are generated annually from the thermal power stations of the country.

In addition to the above, a huge amount of carbon dioxide gas, which is not generally considered as a polluting gas, is released into the atmosphere which in turn enhances the global warming potential.

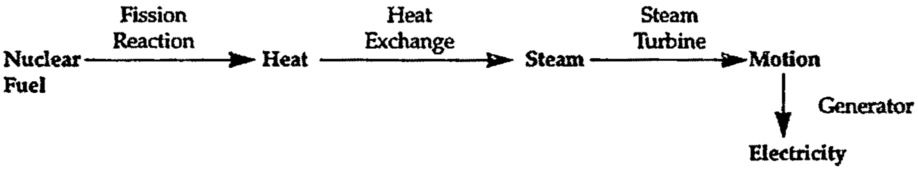
On the other hand, oxides of sulphur and nitrogen, SO_x and NO_x, in the air causes acid rain. Both these events, global warming and acid rain, are detrimental to the environment.

7.3.2. Hydel power

Water when falling from a higher position (level) to a lower position releases energy. This energy of falling water can be harnessed to generate electrical energy in a "Water Turbine". The electric power so generated is called hydro-electric power (or hydel power). Dams are constructed on the river courses in a region having adequate slope of the land, thereby creating artificial water reservoir. The stored water is then led through the water turbine and released on the other side (downward) of the river course. This is the basic principle of hydro-electric power generation. Hydro-electric power generation is completely pollution free and it is also renewable, only drawback of a hydel project is that it submerges large land area and it cannot be built in an earthquake prone area. Silting of the water reservoir is another problem. Some of the examples of the hydel power projects in India are Bhakra-Nangal, Hirakund, Maithon, Panchet and Jaldhaka. The hydel power generated in the country in 1998-99 was over 22000 MW.

7.3.3. Nuclear power

Nuclear power generation is a recent addition to the power sector. The annual generation in 1998-99 was 1840 MW, approximately 2 per cent of the total power generated. This technology has been developing since the 1950's. Certain elements (atoms) having larger degradable nuclei (fissile) can be broken down into smaller components by bombarding them with high energy particles like neutrons. In this process large amount of heat is released.



At the same time neutrons released in chain reaction, would in turn smash new fissile molecules and this process would continue releasing enormous amount of heat energy within a very short time. This is known as "Nuclear Chain Reaction". The first demonstration of "Nuclear Chain Reaction" was the dropping of the first atomic bomb on Hiroshima in 1945. When the chain reaction is uncontrolled, it produces the atom bomb. If this chain reaction is controlled and the number of bombardments is limited to such a low value that the release of heat is also controllable, we can produce electric power in a "Nuclear Power Reactor". A very large number of power reactors are now in operation in the world producing bulk electricity. In India, we have got a number of such nuclear power stations at Trombay, Rana Pratap Sagar, Kalpakkam etc.

Nuclear power stations do not create atmospheric pollution under normal working conditions. But it is a high-risk technology and workers working in the station must take cautionary measures against radioactive hazards. There are instances of fatal accidents in the nuclear power industry, which caused radioactive disaster over a very large area around the station. This results in long term damage to the human society and nature. Two of these disastrous accidents that may be mentioned here were at the Three Mile Island in USA and Chernobyl in Ukraine. If the safety conditions are strictly maintained nuclear power can be a good alternative to the fossil power till other safer technologies are developed.

7.4. Non-conventional sources of energy

The traditional or conventional sources of energy, we have discussed earlier, have some demerits attached to them. Use of wood as a fuel has to be discouraged as it means deforestation, which has adverse environmental effects. Fossil fuels have limited reserve and will be exhausted in a not too distant future. Coal being the most abundant of the fossil fuels has got the highest potential of environmental air pollution. Nuclear power although clean has its safety problems. Hydro-power is a source which is non-polluting and renewable. But big hydro-power projects create other social problems like inundation of prime land and displacement of people from near the project areas.

Since the 1970s, the scientific world is in search of alternative sources of energy, which will be renewable and pollution free. As a result, a number of technologies have been developed and some are in the process of development. The most prominent sources of renewable and non-polluting sources of energy which have been commercially viable are : (i) solar energy, (ii) wind energy, (iii) minihydel energy, (iv) biomass energy, and (v) geothermal energy.

Geothermal energy is not strictly renewable but it is non-polluting.

There are other sources of non-polluting and renewable energy which are still in the research and development stage. Foremost amongst these sources in the tidal energy which is almost on the verge of achieving economical viability. Next in the line is wave energy and ocean thermal energy conversion (OTEC). It will take some more time for these energy sources to be economically competitive. Two of the most prospective and substantial sources of energy are magneto-hydrodynamics and nuclear fusion. The technology for harnessing energy from these sources has not yet been developed fully. But once it is fully developed and commercially viable, our problem of energy and environmental pollution due to production of energy will be almost solved.

7.4.1. Solar energy

As mentioned earlier the spectrum contains radiation broadly divisible into three main regions namely (i) ultraviolet, (ii) visible and (iii) infra-red regions.

The contribution of the radiations having wave lengths greater that 250 nm (long wave region) is negligible in the solar spectrum.

The energy content of the radiations in the various regions including long wave length region are as follows :

(i) ultraviolet region — 8%
(ii) visible region — 45%
(iii) infrared region — 46%
(iv) long wave region — 1%

It has already been mentioned earlier that the solar radiation which reaches at the top of the atmosphere has an average value of 1.2 KW/m^2. While travelling through the atmosphere a portion of this radiant energy is absorbed, scattered and reflected by the cloud, dust particles and gas molecules, leaving on the average, an available radiation on the earth's surface of about 0.9 KW/m^2. This is an enormous amount of energy considering earth's surface area exposed to the sun. Only a small part of this energy is used up for photosynthesis and evaporation (discussed earlier) and a substantial portion of solar energy is still left out. This left out part of the solar radiation can be utilized to supplement energy needs of the human society.

There are two basic routes for the direct utilization of solar energy in its social applications namely, (a) solar thermal route and (b) solar photo-voltaic (SPV) route.

7.4.1.1. Solar thermal route

In the solar thermal route the heat wave portion of the solar spectrum (700 - 2500 nm wave length) is utilized. A number of application-oriented technologies have been developed which can be easily used by the common man. In this way the traditional fuel either wood, or coal or oil is saved and at the same time environmental pollution is avoided.

Solar cooker : Solar cooker is a very simple device in which the solar heat is trapped or concentrated for boiling of foodstuff. There are two types of solar cooker : (a) box type and (b) parabolic concentrated type.

The box type solar cooker is more popular although the parabolic concentrated type can produce higher temperature.

Solar water or air heater : Solar heat can be effectively utilized for heating of water and air. Here again low temperature heating in the range of 70-75°C is done in 'Flat Plate Solar Collector' and for higher temperatures 'Concentrating Collectors' are used. Flat plate collectors are simple to design, fabricate and operate and therefore less expensive. Solar heaters are used for room heating, washing of utensils and laundering. Many industries specially jute, textile and food-processing are now increasingly introducing solar heating devices for saving fuel and in the process reducing air pollution.

Solar distillation and drying : Solar heat can also be used in a specially, designed apparatus for water distillation and crop drying. These devices have also proved to be economically viable.

7.4.1.2. Solar photo-voltaic route

Silicon solar cells are semiconductor devices in which there is generation of electrical potential, when solar radiation falls on it. An array of solar cells can be arranged in what is called a solar panel and it can be used to charge a storage battery, operate a pump to lift water, run a fan or illuminate and electric lamp.

The solar photo-voltaic system has widespread application for street lighting, water pumping and as solar lantern in remote places where grid electricity has not yet reached.

7.4.2. Wind energy

The mechanical energy of wind speed can be harnessed in a wind mill to lift water from a well. This application of wind energy is viable at relatively low wind speeds. But for conversion of wind energy into electricity, higher wind speed of the order of 18-20 km/hr is needed. An especially constructed wind-electric generator is attached to the axle of the wind-mill which generates electricity. Wind energy is non-polluting.

7.4.3. Tidal energy

There are certain coastal areas where tides form in a very prominent way. The difference in level of water in the river between the high tide and the low tide can even be of the order of 6 to 7 m. This difference in water level is utilized to produce hydro-electricity. A portion of the river is blocked in such a way that during high tide, water in this portion of the river is stored at a higher level and during the low tide period, this stored water is allowed to fall to the lower level through a water turbine producing electricity. Tidal energy is also non-polluting.

7.4.4. Geothermal energy

The inner core of the earth is very hot and molten. The temperature is of the order of 4000°C. The earth's crust is on an average 30 km deep. The temperature at this depth is around 1000°C. There are some places where hot conducting rocks are present very near the earth's surface. These rocks cause hot springs or geysers when water comes in contact with these hot rocks. We may also inject water on the identified hot rock area and high pressure-high temperature steam can be produced which in turn can generate electricity. This is a kind of thermal power generation without any polluting fossil fuel burning. The first power plant of this type started generation of power at Hawaii in 1982. The capacity of this power station is 3 mega watt (3MW).

7.4.5. Bio-gas

Bio-gas, or 'Gober gas' as it is called, is also a renewable source of energy. In a traditional gober-gas plant, cowdung is put in a closed vessel where anaerobic digestion takes place with the help of methanogenic bacteria. Methane gas is produced in this reaction, which is used as a fuel; crop residue and other bio-mass materials can also be used to produce bio-gas. There are various designs of bio-gas plants.

Bio-gas can also be produced by wood gasification in a gasifier. In this process 'Producer gas' is produced which is also a fuel. Gober gas plants have become very popular in rural India. A household having 4-5 heads of cattle can utilize the dung in a simply constructed digestion chamber to produce bio-gas, which can be used for cooking and lighting homes. At the same time the semi-solid residue of the reaction is a very good quality biofertilizer.

7.4.6. Mini-micro hydel power

Hydro-electricity is a well developed technology and substantial quantity of electrical power is being produced all over the world through this technique. Hydro-electricity is produced through construction of large dams on the river courses at specific locations.

Mountainous regions have numerous small streams with seasonal or perennial water flow coming down from great heights. These water streams can be utilized to produce small quantities (50 KW to 500 KW) of electricity. More than one small hydro-electric stations alongwith water reservoirs can be constructed on the same stream at different heights. The principle of production of electricity is the same as that of large hydro-electric power stations. The small reservoir and the small power station can provide water and power to the local hill hamlets. Small hydro-electric power potential of India is of the order of 10,000 MW. Government of India in its Ministry of Non-Conventional Energy Sources (MNES) has taken up an ambitious programme of exploiting this clean source of energy to its maximum.

7.4.7. Energy plantation

Plants and trees are the oldest energy sources known to the human society. However, indiscriminate destruction of trees and forests tells upon the environment and ecology. Alternative approach has been to plant exotic varieties of quick growing plants specifically for the purpose of fuel wood. For energy plantation large tracts of non-forest and non-agricultural lands are utilized. Even fallow and degraded lands are being utilized for this purpose. The branches or twigs and leaves of these trees are used directly as cooking fuels or utilized in the gasifier to produce electricity.

7.5. Energy production from wastes

Energy can be produced utilizing wastes from various sources. The major sources are : (i) agricultural waste, (ii) industrial waste, and (iii) municipal waste.

Agricultural wastes are mainly crop residues. When dried they can be used as fuel. Straw, jute sticks and other crop remains are being used traditionally by the village people for cooking and partial boiling of paddy before milling and other heating requirements.

In certain industries, the waste materials can be utilized as a source of energy. Food processing industry, jute industry, sugar industry, paper industry and cotton textiles industry are the major industries where the waste materials can be effectively utilized for the production of heat and electricity. Various technologies have been developed for effective use of the bagasse, jute, cotton and paper residues for energy production.

Both solid and liquid municipal wastes can be the sources of energy. Bio-degradable materials in the municipal waste can be converted into bio-gas through bacterial anaerobic digestion in properly designed digestors. Solid municipal wastes can be dried and pelletized to produce fuel pellets. Also large scale power production can be achieved by burning solid municipal waste by 'Laser Torches'. Some of these technologies are, however, under trial production only.

CHAPTER VIII

ENVIRONMENT AND PUBLIC HEALTH

8.1. Relation between environmental pollution and community health

There is an intimate relationship between environmental pollution and community health. The more the environment is polluted, the more the community health will be disturbed.

Several pillars of community health are : (1) safe drinking water, (2) unpolluted soil, (3) pure air, (4) uninterrupted ventilation, (5) sufficient light, (6) safe limit of sound, (7) minimum nuclear radiation, (8) proper disposal of night soil, (9) removal of garbage, (10) eradication of communicable and other diseases, (11) acclimatization with the weather, (12) preservation of health of people working in different fields.

Environmental pollution related to these fields can create public health problems and may even cripple public health. Human beings themselves are mainly responsible for environmental pollution and all efforts must be made to solve these problems.

8.1.1. Water and soil pollution

For drinking, washing, bathing, cooking etc. 100-150 litres of water are required per person per day. In our country, many people do not get this quantity.

Source of water pollution : (1) Drain water containing faeces, urine and other pollutants, (2) effluents from the factories, (3) water containing chemicals insecticides and manures washed out the field can pollute the water of rivers, lakes, ponds, wells etc., (4) physical pollution such as heat and ionic radiation, (5) minerals above a certain level in the soil, or present in the parent rocks, can mix with water and pollution occurs, such as arsenic.

Source of soil pollution : (1) Excreta of human beings and animals in the field, (2) harmful chemical insecticides and manures, (3) non-degradable plastic materials and cups, plates etc. prepared from foams.

8.1.2. Air pollution

Source : (1) Gases coming out from various factories such as metal or oil refineries, factories where chemical fertilizers and pesticides are manufactured, power plants, etc (2) from the factories through burning of coal, oil, etc. , smoke, dust and various chemicals pollute the air, (3) smokes coming out of motor vehicles containing lead and many other harmful chemicals. This is the main source of air pollution in the cities.

8.1.3. Ventilation

Ventilation is disturbed when rooms are too small or too close, where the area is thickly populated, where doors and windows are not sufficient or absent, and where cross ventilation is not there.

8.1.4. Light

If the source of light is not good and sufficient light is not there, eye strain occurs, the power of sight is diminished. In the rooms and working places, normal daylight should be allowed. Children living in dark rooms, devoid of sunlight, may suffer from rickets.

8.1.5. Proper drainage system and disposal of night soil

Defaecation and passing of urine here and there in the field or roadside should be avoided to keep the environment clean and to prevent the spread of many diseases.

Due to prevalence of service latrines in some areas the environment is also polluted. If drainage system is not properly maintained and adequate disposal of night soil is not done,soil, water and air will be polluted, food and drinking water will be infected through faeces and pests such as flies, cockroaches, rats etc. will prevail.

Disposal of garbage : Garbage may be accumulated on roads, in markets, cattle sheds or stables, factories and households. The garbage should first be stored at a particular spot at a particular time, from where it is to be removed at regular intervals. Various methods for disposing of garbage are—filling up of low land, incineration, burying under the ground, burning, composting for preparation of manure etc.

8.1.6. Noise pollution

Unwanted high pitched sound may create discomfort or disease. The tolerable limit of sound is 60 decibel. In the living area in day time and at night it should be 55 and 40 decibels respectively.

High pitched sound makes the hearing apparatus tired and various difficulties arise. At first whistling is heard, there may be buzzing sound, then temporary or permanent deafness, difficulty in hearing, speaking or expressing something, irritation, mental disturbance, loss of attention, as a result of which efficiency is diminished. Headache, giddiness, dizziness, insomnia, nausea, vomiting, rise of blood pressure, undue pressure on the nervous system, increased perspiration, peptic ulcers, etc. are associated with noise pollution.

8.1.7. Infectious and other diseases

Some of the infectious deseases spread through contaminated water, air or soil, some others are transmitted through blood sucking arthropods. Certain diseases are related to the life style, such as food-oil, ghee, red meat, etc. if taken in excess, heart diseases, diabetes or even cancer may develop. If the diet is deficient in vitamin A certain tumors may develop, green vegetables taken regularly can remove this deficiency. If sugar is taken in excess, dental diseases may occur.

8.1.8. Smoking

Smoking is responsible for a peculiar type of persistent cough, quick exhaustion, long standing bronchitis and emphysema of the lungs. Production of defective sperms increases, memory decreases, blood pressure rises, there may be sudden death mostly in young people from heart attack. There is the risk of cancer of the mouth, lungs, larynx, oesophagus, pancreas and bladder. Pregnant mother having the habit of smoking may deliver a child with low birth weight and there is possibility of death of the child either before or just after birth. Passive smoking of parents may produce pneumonia, bronchitis or asthma in the children. *Bidi,* or any other form of tobacco such as *khaini, zarda,* snuff, etc. are also harmful.

8.1.9. Ionizing radiation

Source : (1) Natural — (a) from the space it is entering the atmosphere of the earth, (b) in the environment there are some metals (radium, etc.) and radioactive gases (radon etc.) from which some emission of ionizing radiation occurs, (c) from the tissues of human body very small amount of ionizing radiation is coming out. (2) Man-made — (a) X-ray, (b) explosion of nuclear bombs, (c) accidents in nuclear power plants, and (d) TV, radium containing watches,etc.

Ionizing radiation is either (1) penetrating (such as X-ray, gamma ray, neutron) radiation can affect the whole body, or (2) nonpenetrating (alpha or beta particles) that cannot penetrate the whole body and only affect the skin.

Diseases and discomforts depend on the dosages of radiation. When atomic explosion occurs or when accidents take place in the nuclear plants or in factories and hospitals where atomic energy is used, the dose of ionizing radiation rises above the danger level of 100 rads (equal to 1 Gy i.e. 1 grey).

When the dose of radiation varies from 75-125 rads, instantaneous symptoms are nausea, vomiting and general weakness. Within a few days the white blood cells and platelets of the blood decrease, the defence mechanism of the body diminishes, there is a risk of leukaemia and other forms of malignant tumors.

If the dose is high (200-1000 rads), in the beginning there is vomiting, then comparatively the patient may feel well, but within 2-3 weeks the white blood cells and platelets will decrease, bone marrow will be depressed, no new blood cells will be formed, bleeding may occur from various sites of the body, many people will begin to suffer from various infectious diseases, death rate will be highly increased. Abdominal symptoms start i.e. vomiting, severe loose stool mixed with the blood, which will not be cured by any medicine. The patient becomes dehydrated and may suffer from various intermittent infections with increased risk of death.

If the dose of radiation is very high the following nervous symptoms will appear—nausea, vomiting, confusion, coma, severe cerebral oedema, death occurs invariably within 36 hours.

Due to ionizing radiation, the following symptoms related to skin may appear—the skin becomes reddish, there is haemorrhage beneath the skin, blisters appear, various secondary infections occur, there is fall of hair. If the hair from all of the body is lost, the consequence is severe. This may happen when the dose of radiation is about 500 rads.

Besides instantaneous symptoms, ionizing radiation can create chronic manifestations. After a prolonged time of exposure leukaemia or cancer (of the skin, thyroid gland, salivary glands etc.) may develop. There may be impotency, sterility, cataract and various defects in the foetus. Genetic change may also occur in the next generation.

8.1.10. Relation of human health to the atmosphere

A person may suffer if not properly acclimatized with the environment. Some examples of stresses are as follows.

(1) Excessive heat : (a) Exhaustion, if there is no prior acclimatization, with the symptoms of giddiness, generalized fatigue and weakness, there may by hypotension, a rise of body temperature, dehydration and delirium. In one day, about 5-6 litres of water and 20-25 g of sodium chloride may be lost from the body. (b) Due to heat, there may be cramp of muscles (specially of leg), which is very much painful. If a person works very hard, in the hot atmosphere, this may occur. If one takes water and salt (25 g sodium chloride and 5 litres of water in the first 24 h) cramp will subside. If extra salt is added to the food, risk of cramp is lessened. (c) Heat stroke occurs in hot humid climate with little cooling wind, even without exercise. It is a life threatening condition. Symptoms are headache, nausea, vomiting, weakness, sweating may stop or it may continue, confusion, delirium and coma may take place. The patient should immediately be transferred from hot humid weather to a cold place, his whole body should be immersed in cold water, if ice is available it should be applied to keep the body cool. If the treatment is done immediately, the patient recovers very quickly, but if there is any delay, there is risk to life. Complications from heat stroke are (a) shock, (b) renal and hepatic failure, and (c) cerebral oedema.

(2) Excessive cold : When the patient is not well clad in the cold weather for a prolonged period there is shivering. The body becomes numb with loss of sensation to touch, muscular weakness, desire to sleep, unconsciousness and death. In the temperate region, there may be snowfall and the tissue is frozen, necrosis (death of tissue) occurs, fingers, toes and parts of limbs may have to be amputated.

(3) Lack of mositure : If the weather is very dry, nostrils become dry, possibility of infection through nasal passages is increased.

(4) Rain : If drenched, a person may feel cold with uneasiness. There is risk of laryngitis, pharyngitis and respiratory infections such as influenza, pneumonia, tuberculosis, etc.

(5) Electric shock : If mild, it can give a painful sensation, which is awful, but not so much dangerous, no sequel is left on the skin or in the nervous system. If the dose of electric shock is high (such as lightning strike) the pulse rate becomes high, muscular contraction occurs, often there is damage to the spinal cord. Lightning may cause a fan-shaped burn on the skin or necrosis of subcutaneous tissue due to the heat generated by electricity.

(6) **Smoke** : In the smoke there may be hot air, gases and carbon particles coated with aldehydes and organic acids. If plastics are burnt, carbon monoxide and hydrochloric acid get mixed with the smoke. If anybody remains for a prolonged time in the smoke, respiration becomes difficult due to low oxygen, one may be choked, there may be laryngeal constriction and stridor, dyspnoea and pulmonary oedema, which are dangerous signs, the patient may even die. Treatment is to remove the patient from the smoke; oxygen is to be given. Often intensive care is necessary.

(7) **Carbon monoxide (CO)** : The gas is present in cooking smoke and in the emission coming out from motor vehicles. When any kind of combustion is going on without the presence of adequate oxygen, CO is produced. CO mixes with haemoglobin of the blood and a different compound is formed, as a result of which oxygen cannot be attached to the haemoglobin. Symptoms include headache, nausea, vomiting, characteristic pink colour of the skin, enlargement of the heart, mental weakness and convulsion, loss of sense and death.

8.1.11. Preservation of health of people engaged in different jobs

Those who are employed in different jobs, environment for them is at times bad to worse. Deterioration of environment would cast its shadow on the efficacy of the workers, damaging their health. There are several factors that affect the health of workers.

8.1.11.1. Industrial workers

(a) Physical factors : Too much heat or cold, dampness, less circulation of air, insufficient or dazzling light, emission of heat, ionizing radiation,noise, too much vibration etc. can hamper their health. There may not be adequate facilities for toilets, washing of hands and feet, bathing etc., affecting the health of workers.

(b) Chemical factors : If there is no proper protection, workers in various factories may come in contact with various toxic chemical substances, smoke, gas etc. which may damage the lungs, skin, blood and other organs of the body.

(c) Biological factors : Various viruses, bacteria and parasites may infect the workers with severe consequences. These disease-producing organisms may enter the body through polluted water, soil, air and food or through animals from their secretions and excretions especially when the workers remain in close contact with them.

(d) Machines : If unprotected, not installed properly, old and defective, not supervised adequately and safety measures are not maintained, chances of accidents from machines are there.

(e) Personal and public relations : If there is strained relation between the workers themselves or between the workers and the management, various difficulties are encountered related to distribution of job, promotion, insecurity, mental agony, etc., consequently the health of the workers may be adversely affected.

8.1.11.2. Health problems of agricultural workers

(1) **Accident** firstly from the machines they use, secondly from poisonous animals such as snakes, bees, wasps, hornets, scorpions, centipedes, etc.

(2) **Infectious deseases** such as filariasis, Japanese encephalitis, typhus, Kyasanur forest disease, anthrax, Weil's disease, tetanus, tuberculosis,.hook worm, schisotsomiasis (not present in India) etc.

(3) **Adverse physical conditions and weather** can affect the health of agricultural workers such as noise, vibration, excessive rain, cyclone, flood, drought,etc.

(4) **Toxic chemical and manures**—During handling of toxic chemicals and manures, agricultural workers may suffer from skin diseases. Serious toxic manifestations may occur threatening the life of the victim.

8.2. Important water borne diseases

Water borne diseases may be broadly classified on the basis of their causative agents.

8.2.1. Viral, bacterial and other diseases

Causative agent	Name of the disease
A. Virus	1. Hepatitis A 2. Hepatitis E 3. Poliomyelitis 4. Diarrhoea caused by rotavirus 5. Diarrhoea caused by Norwalk virus
B. Bacteria	1. Cholera 2. Bacillary dysentery 3. Typhoid 4. Paratyphoid 5. Several other bacteria causing gastroenteritis 6. Weil's disease (leptospirosis)
C. Protozoa	1. Amoebiasis 2. Giardiasis 3. Cryptosporidiosis
D. Helminths	1. Guineaworm disease 2. Schistosomiasis (not present in India)

8.2.2. Toxic metals in water

Any toxic metal, such as lead, arsenic, selenium, mercury, cyanide, cadmium etc., if present in water beyond the tolerable limit, may be harmful to the body. If fluoride is present in very low proportion, dental caries may occur. Excess of fluoride is associated with abnormal increase of bones causing pain.

8.2.3. Prevention of water pollution related illness

(1) Safe drinking water should be taken; corporation or municipal tap water or water from deep tubewell is usually safe. (2) In hotels, restaurants, marriage feasts, picnics, parties etc. water should not be taken, as there is risk of contamination. (3) After defaecation, both the hands are to be washed with soap and water. (4) Processed or cut fruits sold openly, **sherbet** (sweetened, flavoured and coloured cold water), cold water, ice, icecream, etc. from the roadside vendors should not be taken to avoid the risk of contamination. (5) Before eating, hands should be washed with soap and water. (6) Ordinary filters are not very effective to prevent water pollution. When water is passed through ultraviolet rays, it becomes safe. (7) Boiled water is safe. (8) If it is thought that the drinking water is not safe, bleaching powder may be added (2.0 g per 1000 litres). (9) Raw unfiltered Ganges water, water with which a deity has been washed, special offerings prepared with flour, sweets etc. are usually contaminated.

8.2.4. Important soil transmitted deiseases

Bacteria — If any wound is contaminated with dust or soil, (1) streptococcus or staphylococcus infection occurs — boils, pus etc. may be formed, (2) there is the risk of tetanus.

Helminths — People may defaecate in fields and soil becomes contaminated with the eggs of round worm, whipworm, etc. While playing on the soil, eggs may be attached to the nails and fingers of the children, which may be swallowed. Thus the children are infected. Soil may also contain the larvae of hook worms. If some one walks bare footed, the larvae can penetrate the skin of the feet, enter the body and ultimately reach the intestinal canal.

Fungus — From contaminated soil, fungal diseases can also be transmitted. Soil may be contaminated with pesticides. From the soil pesticides may be accumulated in fruits, vegetables and food grains. When these materials are consumed, the pesticidal residues may enter the body and accumulate there and can create health hazard. Many chemical fertilizers and insecticides in this way can enter the body.

Prevention of soil transmitted diseases : (1) People should not walk bare footed on the soil. (2) To avoid risk of tetanus from contaminated soil, tetanus toxoid injection is to be taken. (3) If the wound is soiled, it should be washed properly and some bactericidal ointment is to be used. (5) Children should not play on those grounds where soils are contaminated with the helminthic eggs. (6) Instead of toxic agri-chemicals, fertilizers etc., people should be encouraged to use biological substitutes.

8.2.5. Important diseases transmitted through air

Influenza — causative organisms may be viruses or bacteria
Pneumonia — causative organisms may be viruses, bacteria or fungi

Measles	Virus
Chicken pox	
Tuberculosis	Bacteria
Leprosy	
Whooping cough	
Diptheria	
Anthrax	

Coal dust from coal mines, fumes during processing of gold or silver with acids and chemicals, mica or lead particles mixed with dust or sand from respective mines or processing plants, asbestos powder, fine cotton fibres from cotton factories, fine fibres of sugar cane from sugar factories, dust and fungi from agricultural farm houses may enter the lungs and may produce disease or damage the lungs.

Gases emitting from varnishing works, paint manufacturing plants, colour-washing units, electronics factories, metal processing plants, refineries, battery factories etc. can produce allergy, bronchitis, etc.

Prevention : (1) One should not spit or spittle or discharge cough and nasal secretions anywhere and everywhere. (2) Vaccines are there for measles, tuberculosis, whooping cough, diptheria and chicken pox. (3) Taking food together from the same plate should be avoided, left-over food should not be taken by other persons. (4) A child usually sucks the toys, such toys should not be used by other children. (5) It is possible to check air pollution if chimneys of factories are constructed according to the height required to reduce emission of smoke.

8.2.6. Important diseases from contaminated foodstuff

(1) Food materials may be infected with viruses, bacteria or protozoa. Toxins coming out from the body of bacteria may contaminate the food. If such food is taken toxic manifestations are produced. Food materials which are kept for a prolonged period (such as salad, rice cooked overnight and kept steeped in water), an oblation of sweets offered to deities (*sinni*). The water with which feet of deity or a revered person has been washed (*charanamrita*), food offering to a deity or remains of food taken by a venerable person), contaminated ice, icecream or cold drink, food kept in dirty utensils, uncovered food, stale food polluted by excetions and secretions of ants, flies, cockroaches, rats, cats, etc. (2) Susceptible persons may suffer from allergy if they take prawn, crab, strawberry, etc. (3) Some fish and mushroom or mould are toxic. Rotten fish may be contaminated with bacteria and if taken severe toxic manifestations may occur. (4) If raw or half-cooked pork or beef is taken, a person may be infected with tape worm. (5) Crabs, some sort

of fish, snails etc. if taken raw or under-cooked may cause suffering from various flat worms which infect the lungs, liver and intestine. (6) Contaminated snails, prawns, shrimps, crabs, etc. when taken raw or half-cooked may transmit cholera.

Disease from the arthropods

Name of the arthropod		*Disease*	*Causative organism*
Mosquitoes	**Anopheles**	**Malaria**	**Protozoa**
	Culex, Mansonia	**Filaria**	**Helminth**
	Culex	**Japanese encephalitis**	**Virus**
	Aedes	**Dengue**	
		Dengue haemorrhagic fever	
		Chikunguniya yellow fever	**Viruses**
		(not present in India)	
Sand fly		**Kala-azar**	**Protozoa**
		Cutaneous ulcers	
		(= Cutaneous leishmaniasis)	**Protozoa**
		Sand fly fever	**Virus**
Flea		**Plague**	**Bacteria**
		Murine typhus	**Bacteria**
Body louse		**Endemic typhus**	**Bacteria**
		Trench fever	
		Relapsing fever	
House fly, cockroach, rat		**Amoebiasis**	**Protozoa**
		Giardiasis	
		Poliomyelitis	
		Hepatitis A, E etc.	**Virus**
		Cholera, Typhoid,	**Bacteria**
		Paratyphoid, Anthrax,	
		Dysentery, Enteric deseases,	
		Leprosy, Tuberculosis, etc.	
		Round worm, Whip worm,	
		Hook worm etc.	**Helminths**
Ticks		**Typhus**	**Bacteria**
		Relapsing fever	
		Kyasanur Forest Disease (KFD)	**Virus**
Mites		**Scrub typhus**	**Bacteria**
		Scabies	
Cyclops (Water flea)		**Guinea worm**	**Helminth**
Diseases from pet animals and rodents			
Dogs	**Rabies**	**Virus**	
	Hydatid disease	**Helminth**	
Cats	**Toxo plasma**	**Protozoa**	
	Trichinellosis	**Helminth**	
Rats	**Plague**	**Bacteria**	
	Weil's disease	**Bacteria**	

8.2.8. Different factors of environment linked with cancer

Factor	*Example*	*Susceptible subjects*	*Type of cancer*
Physical	Ultraviolet ray	Cultivators,sailors	Cancer of the skin
	Atomic radiation	Nuclear power plant workers Nuclear explosion victims	Lukaemia Cancer of the breast, thyroid, lungs, etc. Melonoma of the skin
Chemical	Tar, oil, soot	Chimney sweeper	Skin cancer
	ß-naphthylamine	Chemical factory	Bladder cancer
	Asbestos	Asbestos factory workers, Insulation workers	Cancer of the Lungs Leukaemia
	Benzene	Varnisher, glue worker	Liver
	Vinyl chloride	PVC industry workers	Liver cancer
	Aflatoxin — this is found in certain fungi that infest nuts, maize, peas, millets, sorghum, etc.	Domestic animals and other consumers	
Viruses	Hepatitis B virus — 10% of those infected with this virus have the risk of cancer		Liver cancer
	Human papiloma virus		Uterine cancer
	Epstein Barr virus		Nose and throat cancer, lymphoma
	HIV virus		Has got some relation to Caposi's sarcoma, Non-Hodgkin's lymphoma and Lymphoma of nervous system and Hodgkin's disease
Helminth	Schistosoma haematobivus	(Schistosomiasis — not present in India)	Bladder cancer
Chlonrochis sinensis (lung fluke)			Liver cancer
Life style	Smoking		Cancer of the lungs, mouth cavity, larynx, oesophaghs, bladder,etc.
	Faulty food materials containing excess of fat, etc. Alcohol		Breast cancer, gut cancer, cancer of the oesophagus, liver cancer
	Contraceptive pill		Liver cancer

8.3. Human malaria parasites

Malaria parasite is an unicellular organism. There are four species of human malaria parasites :

1. ***Plasmodium vivax***
2. ***P. falciparum***
3. ***P. malariae***
4. ***P. ovale***

In India, ***P. vivax*** and ***P. falciparum*** contribute about 60% and 40% of all malaria cases respectively. Percentage of ***P. falciparum*** malaria is increasing in recent years. Number of ***P. malariae*** cases is very few, usually found in some tribal people. ***P. ovale*** infection is rare in India.

There is practically no possibility of death due to ***P. vivax, P. malariae*** or ***P. ovale*** infection. Death may occur in a few falciparum cases if not diagnosed and treated early and if complications arise.

Human malaria is transmitted from man to man through the bite of infective female ***Anopheles*** mosquitoes.

No other animal can act as its carrier and reservoir.

8.3.1. Life-cycle of malaria parasites

There are two stages namely asexual and sexual.

I. Asexual cycle (inside the body of human beings) : In this stage the parasite begins to multiply, first in the liver cells, then in the red blood cells (RBCs).

An infective female mosquito carries the germ in her salivary glands. When she bites a man, before sucking the blood, she discharges the germs mixed with saliva into the blood stream of the victim. After half an hour or 45 minutes these germs cannot be detected in the blood. Many of them die, those who survive, invade the liver cells through the blood stream. One sporozoite enters one liver cell and begins to divide. One liver cell may contain several thousands of multiplied germs; ultimately the infected liver cells burst. Thousands of parasites are released in the circulation. They invade RBCs, their ultimate habitat and one parasite usually enters one RBC.

In the RBC the parasite multiplies for the second time. In one RBC one parasite divides into 6-36 segments. The RBC ruptures and the liberated parasites invade other healthy RBCs. Thus at the interval of 48 hours (or in ***P. malariae*** 72 hours) the infected RBCs burst (for which fever occurs) and the parasites go on multiplying, destroying the RBCs.

In ***vivax*** and ***ovale*** malaria a few germs instead of multiplying in the liver cells remain dormant, (as if they are sleeping) known as hyprozoites. When they get any opportunity, at the interval of weeks or months, they start multiplying and attack RBCs. Thus relapse occurs. In ***falciparum*** and ***malariae*** malaria this hyprozoite stage does not exist, hence relapse does not occur.

Some parasites after entering the RBCs do not multiply, they are converted into male or female parasites. They are mainly responsible for malaria transmission.

II. Sexual cycle (inside the body of female Anopheles mosquito) : Sexual stages of the malaria parasite circulating in the blood of a malaria patient will be taken over by the female *Anopheles* mosquito. In the stomach of the mosquito, the male and female parasites unite, begin to multiply, spread throughout the body of the mosquito and the germs ultimatley enter the salivary glands. In the salivary glands of a mosquito as many as 300,000 germs may be present.

Why does the female Anopheles mosquito transmit malaria, not the male? The mouthpart of the male mosquito is thin and blunt, hence it cannot pierce the skin and suck the blood. The female mosquito takes blood for its biological need. If it does not take blood, it cannot produce viable eggs.

Except *Anopheles* no other genera of mosquito (such as *Culex, Aedes,* etc.) are able to transmit human malaria, as in them human malaria parasites cannot survive or multiply. That is why only the female *Anopheles* mosquitoes are the vectors of malaria.

It takes 8-16 days to complete the sexual cycle of the parasite in the mosquito, i.e. 8-16 days after taking the blood of a malaria patient the mosquito can transmit malaria, not before that. Once infective the mosquito remains infective throughout its life.

Thus partly in the body of human beings and partly in the body of mosquito the life-cycle of malaria parasite is completed. If we want to control or eradicate malaria, we shall have to break the cycle somewhere.

Effective treatment can destroy the parasite in the body of human beings, then the parasites cannot multiply.

If male and female parasites are present in the blood of human beings, they can be killed by specific medicines, then the mosquito may take the blood of man but cannot transmit malaria.

If the mosquito cannot bite a human being, she cannot collect and carry the malaria parasite and cannot transmit malaria.

If it is possible to reduce the density of mosquitoes at a certain level they cannot transmit malaria. So mosquito control helps to control malaria.

8.3.2. Environmental, biological, chemical and biotechnological control of mosquitoes, flies and other domestic pests

To control the arthropods transmitted diseases (1) environmental measures, (2) personal protection and (3) various physical, chemical and other methods are adopted.

8.3.2. 1. Improvement of environment and upgrading sanitation

(A) To keep the environment clean (a) garbage should be kept in a covered container and disposed of at regular interval, (b) for safe disposal of faeces use of sanitary latrine should be used, and (c) food items should always be kept covered. If these measures are taken, flies, cockroaches etc. cannot pollute the environment.

(B) Filling and levelling of low land and ditches surrounding the home will prevent accumulation of water and breeding of mosquitoes.

(C) If flow is maintained in the open drains, mosquito larvae would be washed away.

(D) Bushes and shrubs surrounding the houses, that are hiding places of mosquitoes and undesirable animals, should be cut and cleaned.

(E) Accumulation of sulluge water from the sanitary tanks is a source of mosquito breeding. Such water is to be drained out.

(F) Underground drains and modern sanitary arrangements prevent mosquito breeding and help to keep the environment clean.

(G) Construction of buildings, rails, roads, dams, etc. may invite mosquito breeding if proper precautions are not taken beforehand.

(H) Tiny mud huts with small windows, thatched roofs are ideal hiding places of mosquitoes, sandflies, cockroaches, etc. On the other hand big rooms, big windows, tin or asbestos roof are not suitable for hiding.

(I) *Armigeres* mosquitoes (they do not carry any disease, but bite in day time) breed inside the sanitary tanks. If vent pipes of the sanitary tanks are covered with nets, these mosquitoes cannot enter and breed there.

(J) Where ***Pistia*** plants are there in the tanks in villages, a species of mosquito (***Mansonia*** — can transmit brugian filariasis) can bred, the larvae and pupae remain attached to the roots of those plants and complete the life cycle. If ***Pistia*** plants are removed, these mosquitoes cannot breed.

(K) If the level of water in the field is suddenly lowered, mosquito larvae will be killed.

8.3.2.2. Personal protection

(a) Mosquito curtain : If mosquito curtain is used, risk of mosquito bites are considerably lessened as most of the vector mosquitoes (except *Aedes*) bite at night. There should be some provision for mosquito net in the budget of the family. Children must be kept inside the bednet at night. Insecticide-impregrnated mosquito nets are now available. Any insect, coming in contact with it will ultimately die. The insecticide (synthetic pyrethroid) used is not harmful to human beings. In Zambia, Africa, using insecticide impregnated mosquito nets, it has been possible to reduce the rate of child death due to malaria by up to 50%.

(b) Adequate clothing : Hands and feet should be covered with full sleeve shirts, trousers, socks, etc. from the evening onwards. Men usually suffer more from malaria than women. One of the reasons for this is that the females are more well-clad and covered than the males.

(c) Repellants : They can be applied on the exposed parts of the body, such as legs, feet, hands, nape of the neck, face, etc. Dimethyl phthalate, diethyl toluamide (Deet) etc. can repel insects. Neem seed oil also possesses this property and can repel blood sucking insects for several hours.

Those who can afford, can use nets to cover windows, etc. to prevent entry of insects. Nylon nets are available in the market.

If kept adequately covered, food materials will not be contaminated by flies, cockroaches etc.

8.3.2. Source reduction of mosquito larvae

The best method of control of mosquito is the source reduction of the larvae. In the life-cycle of the mosquito there are four stages—egg, larva, pupa and adult. The first three stages are aquatic. In the big cities including Calcutta stress is given on searching of larvae spots to kill them. In Calcutta, ***Anopheles stephensi*** the vector of malaria and ***Aedes aegypti,*** the vector of dengue and DHF breed in small collection of sweet water in and around houses in masonry tanks,unused empty tubs, drums, broken utensils, flower-vases, ant-guards, water reservoirs, roof gutters, broken pipes, tyres, air conditioners, refrigerators, construction sites etc. These types of breeding spots are to be identified and destroyed at source.

8.3.2.4. Biological control

This is gaining importance day by day taking effective part in killing mosquito larvae. Examples : (a) A bacteria, ***Bacillus thuringiensis*** can enter the body of the larvae and destroy it. It is not harmful to human beings or any other animals except mosquito larvae. It does not pollute the environment. (b) ***Bacillus sphaericus*** can also kill only the larvae of mosquitoes. There bacilli can remain in the environment and can be recycled and if establised in nature can natrually control the larvae. Guppy fish is very efficient in devouring mosquito larvae. Other larvivorus fishes are gambusia, tilapia, etc. Fish can be released in masonry tanks, reservoirs, etc to control mosquitoes.

8.3.2.5. Insecticide

Insecticides are those chemical substances, which can kill the arthropods. There are different types of insecticides which act differently.

(a) Stomach poison — when it is taken by the larvae, toxic action starts such as paris green to kill ***Anopheles*** mosquitoes, (b) **Contact poison** — such as pyrethrum when an arthropod comes in contact with such poison, it enters the body of the arthropod through its skin or respiratory passage. This type of insecticide is sprayed in the air, (c) **Residual insecticide**—when sprayed on the wall remains for many weeks or months. When any insect takes rest on such sprayed well, the insecticide enters it body and the insect is ultimately killed. Examples include DDT, gammexane (organochlorine), malathion (organophosphorus), sevin (carbamate), deltamethrin (synthetic pyrethroid), etc., (d) **Gas,** such as hydrocyanic acid, sulphur dioxide, methylbromide, etc.

Use of insecticides

(a) Residual spraying : Before spraying an insecticide, a survey is done, whether the target vector has become resistant to the selected insecticide or not. For example to control sandfly (vector of kala-azar) DDT is still effective, but ***Anopheles*** vectors of malaria have become resistant to DDT in many regions. In such cases, malathion is used. If the vector has become resistant to malathion, synthetic pyrethroid insecticide is applied.

In the cities residual insecticides are not effective because most of the vectors have become resistant to most of the insecticides. Further the behaviour of the vectors have changed. For example, ***A. stephensi*** (the vector of malaria in Calcutta) will take blood and fly outside without taking rest on the sprayed wall. So source reduction is the best method for controlling the mosquitoes in the cities.

(b) **Space spray** : The insecticide is sprayed in the air with the help of a pump or a machine. If mosquito or any other insect is there, it is usually killed then and there. Pyrethrum (obtained from chrysanthemum) is such an insecticide, not harmful to man, but it is to be mixed with kerosene before spraying. It remains active for a limited time and therefore requires respraying.

(c) **Spraying insecticidal smoke from a gun or vehicle-mounted machine :** This usually contains malathion or pyrethrum, pollutes environment, mosquitoes move from one site to another, cannot be sprayed evenly everywhere, cannot reach high-rise buildings, when applied mosquitoes may not remain in the room, gives false protection, there is wastage of money.

(d) **Mats, coils etc. :** They also pollute the environment, raise a sense of false protection, affect the health of children.

To kill head louse or body louse, usually gammexane lotion or ointment or powder may be used.

(e) **Chemical control of larvae of mosquitoes :** When it is not possible to kill the larvae by physical methods at source, chemical larvicides are used. For example (a) Diesel oil or malariol is sprayed on the water surface, the oil floats, the larvae cannot take oxygen and die. The oil is to be sprayed at an interval of 7 days. It is not very effective, because if the oil film is broken, the larvae can take oxygen to live. It is costly. (b) Phenthion. (an organophosphorus insecticide) may be sprayed at an interval of 10 days. But these chemicals are not ecofriendly. Prolonged usages have reduced their efficacy, larvae in some places have become resistant to these larvicides, these chemicals are toxic to human beings and other aquatic organisms, some of which actually kill mosquito larvae in nature, including fish. The use of such chemicals is to be restricted. Instead of these harmful chemicals, now-a-days ecofriendly biolarvicides (such as ***Bacillus thuringiensis, B. sphaericus;*** etc.) are used.

(f) **Insecticides used as baits :** Formaldehyde is added to milk to attract flies, cockroaches etc to kill them — Diazinon 1 part is mixed with 24 parts of sugar, and blackened with soot is used as a fly bait. To kill cockroaches propoxur (Baygon) as a bait is used.

(g) **Repellents :** When applied on the exposed surface of the skin they will repell the insects. Examples : dimethyl phosphate (DMP), diethyl toluamide (Deet), neem seed oil, etc.

8.3.2.6. Quarantine

Insecticide application and disinfection of air-planes before they arrive at the air port, disinfection of ships to prevent introduction of rats, etc. and also of air-planes coming from endemic areas (of yellow fever, etc.) are effective measures.

8.3.2.7. Other methods

(a) **Sterilization :** Male mosquitoes can be made sterile with the help of medicine or by applying gamma radiation. It is expected that as a result of mating with these males, no viable offsprings will be produced.

(b) **Genetic control :** By introducing hybrid sterility, cytoplasmic incompatibility, distorted sex ratio, mosquito population can be reduced.

(c) **Light trap :** Use of light trap can kill certain arthropods.

(d) **Pheromone trap :** This can be used where insects of opposite sex will be attracted and killed.

(e) **Sound wave :** A particular insect may be attracted by a particular sound wave and can be trapped and killed.

Uptil now these methods have not taken effective roles to control arthropods, but in future with the help of modern technology, particuarly with the advancement of biotechnology, spectacular improvement in mosquito control operations is expected.

8.4. Risk of using chemical insecticides in the agricultural field, integrated control procedure, biological control and use of biotechnology

India is mainly an agricultural country. The most important enemies of crops, fruits, vegetables and trees are arthropods. To kill them various chemicals are used. All of them are poisonous, can enter the body through skin, respiration, food or accidental ingestion, producing toxic manifestations.

Poisoning may occur (1) in the factory, where the insecticide is manufatured, (2) when the insecticide is processed, prepared or mixed for application in the field, (3) when the insecticide is sprayed to kill or control the arthropods (4) when the insecticide is kept in the room unprotected, (5) some insecticide sometimes is taken deliberately to commit suicide, (6) inside the grains, fruits and vegetables the insecticides used may go on accumulating and when human beings take these insecticide-contaminated things, traces of insecticides are progressively deposited in the body.

To prevent such absorptions and accidents sufficient caution is required. The workers should use masks, so that the insecticide cannot enter the respiratory or intestinal passages. They should use gloves, shoes and other coverings so that insecticide cannot come in contact with the skin. The dress should be changed regularly after the work, washed and cleaned before further use. Where insecticide is used, food material should be kept adequately covered. After the work the workers should thoroughly wash hands and feet before taking any food. Insecticide should never be kept unprotected in the room. It should always be kept away from the children. If it is kept in the room it should be properly marked as poisonous and dangerous. Insecticides which can accumulate in the foodstuff should not be used. Use of ecofriendly or ecohelping insecticides (such as biocides) should be advocated.

8.4.1. Toxic manifestations of insecticides

Organochlorine insecticides : DDT (dichlorodiphenyl tricholoroethane)—Headache, lassitide, sensation of pin-prick or numbness, trembling of hands and feet appears, convulsion. From toxic manifestation of DDT, practically there is no possibility of death.

BHC (benzene hexachloride or gammexane)— In gaseous form the insecticide may enter through nasal passage and mouth. There may be sense of suffocation, urticaria and allergic manifestations of the skin. From this insecticide also, there is practically no possibility of death. This has been banned.

Dieldrin—It is easily absorbed through the skin, producing allergy, utricaria, etc. There may be loss of appetite and convulsion like epilepsy, the patient may die. It is also dangerous for fish and other animals. It has been banned.

Most of the arthropods have acquired resistance against DDT. DDT can kill the aquatic insects, reducing the food of fish. If DDT is used in excessive dosages, fish may also be killed, or even if it is not killed, DDT is accumulated in sufficient quantity in the body of fish. When the bird eats the fish, the fertility of the bird becomes reduced. Through the food chain, in the body of human beings also, DDT is being accumulated. In the human milk the presence of DDT has been noted. In the pasture if DDT is sprayed, it enters the body of the cattle through grass and ultimately may come out with the milk. Even in the eggs of poultry and ducks DDT has been detected. For these reasons DDT has been banned in agricultural fields in India.

Most of the insects have also become resistant to BHC. Besides, in the human body the amount of BHC is increasing day by day. So this has been banned in India.

Organophosphorus insecticides : (malathion, diazinon, fenthion, baytex, fenitothrion, etc.) —Toxic manifestations are contraction of the pupils, feeling of coldness, salivation, nausea, vomiting, diarrhoea, cramp in extremities, low pulse rate, convulsion, spasm of respiratory passage, pulmonary oedema. Risk of death is high. Death usually occurs due to stoppage of respiration.

Carbamate. (propoxur, carbonil, sevin) — Toxic manifestations are like organophosphorus compounds, but the patient usually survives.

Cyanide : Cyanide is used as a rat poison. Agricultural manures contain cyanide. When foam is burnt, cyanide is present in that gas. Cyanide can be taken as a mistake or the gas may enter the respiratory passages. Toxic manifestations occurs within in a very short time, there is giddiness, reeling sensation, headache, difficulty in breathing, shock, the patient becomes senseless. The colour of the skin becomes red.

Paraquat : (paraquat dichloride) — This is used to kill weeds in agricultural fields. It is obtained in liquid or powdered form. In paraquat poisoning there is severe inflammation of conjunctiva and cornea, the eyes may be lost. If it comes in contact with the skin, there are severe allergic reactions and burning sensation and blisters may be found. If it enters the lungs through the respiratory passages pharyngitis and laryngitis occur, blood may come out with cough. If taken by mistake, painful sensation occurs in the mouth, oesophagus and abdomen, ulcers appear in the lips, tongue and pharynx. Other symptoms are nausea, vomiting, prostration, asthama, convulsion, respiratory distress, pulmonary oedema. The heart or kidney may fail. Death takes place due to stoppage of respiration.

Synthetic pyrethroid : (deltamethrin, etc.) — This is the most costly insecticide. Toxic manifestations are practically nil in human beings. In some person, skin allergy may be seen. Even then, during the spray operations, caution is to be taken.

8.4.2. Integrated control

In the agricultural fields now-a-days mainly organophosphorus, carbamate and synthetic pyrethroids are used. None of them are ecofriendly. Many beneficial arthropods and other animals are killed. Over and above, many arthropods have become resistant to most of those chemical insecticides. Their efficacy is decreasing day by day. They are also costly. Health of human beings and other domestic animals is adversely affected by there insecticides.

At present it is probably not possible to discontinue these chemical instcticides but people are searching for alternative methods. To control the pests, stress is being given on integrated control procedures in which pests are attacked from various angles, using different procedures. Some such new procedures are :

8.4.2.1. Biological control

(a) Poison obtained from a bacteria (***Bacillus thuringiensis*** kurstaki) is used to kill caterpillars (Lepidoptera). The toxin of this bacillus is not harmful to human beings or any other animal. It specifically kills the caterpillars. So it is target-oriented and ecofriendly.

(b) In the agricultural fields to save the seed and soil from the fungi, another type of bacterial toxin is used which is obtained from the bacteria ***Trichoderma viridae.***

(c) A virus (nucleopolyhedrosis virus) is used to kill certain pests of tomato.

8.4.2.2. Biochemical products from plants

From Neem (***Azadirachta indica***) a kind of biochemical alkaloid azadirachtin is obtained that is used to kill aphids, jussids and white fly. These biochemical substances act as antifeedants.The insects are also repelled.

8.4.2.3. Hormone

Pheromone is a kind of sex hormone of insects. In a trap, male or female hormone is used to attract female or male insects, respectively which are then killed. A form of pheromone is used to kill ***Podoptera,*** infesting cabbages and cauliflowers.

8.4.2.4. Gene technology

By changing the genes it is possible to produce such type of insect resistant plant so that the insects will not be able do any harm to the plant. In the new millenium this type of technology can bring some sort of revolution in the field of pest control. Trees, shrubs, crop plants etc. can be protected from the pests simply by changing genes. It would also be possible to introduce relevant genes in plants, as a result of which the transgenic plants would be protected from harmful chemicals.

8.5. Toxic actions of metals and biological substances — nature and prevention

8.5.1. Metal pollution

8.5.1.1. Lead

Source : (1) In more than 200 industries (storage battery, glass, press, rubber, pottery, porcelain, shipbuilding,etc.) lead is used. (2) Thousands of tons of lead per year are emitted from motor vehicles. It is one of the few trace metals that is abundantly found on the ground—polluting environment. (3) Water may be contaminated when lead pipe or lead container is used. (4) Colourful toys of children contain lead. (5) Contamination occurs when lead-soldered utensils are used for eating and drinking purposes. (6) Where lead is melted, it is deposited on the roads and surrounding areas, on fruits, vegetables and plants. (7) In the potteries to make the utensils bright and to paint them with different colour, lead is used as a primer. (8) Attracted by the sweet smell, children may lick the toys or even walls and window sills where lead paints have been applied.

Lead enters the body (a) mostly through inhalation, less commonly (b) by ingestion or (c) absorption through the skin. Lead is excreted from the body very slowly and it is ultimately accumulated in the bones.

Signs and symptoms of lead poisoning : Colicy pain in the abdomen, severe constipation, blue line in the gum, loss of appetite, nausea, vomiting, loss of elasticity of muscle, anaemia, wrist drop and foot drop are common symptoms. Nervous manifestations are insomnia, headache, mental confusion, delirium, unconsciousness and coma.

Prevention : (1) Whereever possible other materials are to be used instead of lead compounds. (2) Industries producing lead dust or fume should be situated away from the locality, enclosed and segregated (3) To remove lead fume and dust quickly from the factory adequate ventilation system should be installed. (4) In some places there is possibility of accumulation of lead dust on the floors, sitting places, machines, etc. These should be kept clean by wet sweeping regularly. (5) Atmosphere of the lead factories should be monitored at regular intervals, so that the level of lead remains within the permissible limit (below 2.0 mg per 10 cubic metres of air). (6) Health of the workers should be regularly monitored. (7) Workers should use protective masks or respirators. (8) Personal hygiene, such as washing of hands and feet before leaving the factory and washing hands before taking food should be maintained. No food article should be taken inside the factory. (9) There should be sufficient arangement for washing, bathing, etc. in the factory. (10) Health education should be given, so that the workers become aware and conscious.

If diagnosis of the patient suffering from lead poisoning is done at an early stage, and if the source of poisoning is identified and proper treatment is instituted, the effect of poisoning will be removed.

8.5.1.2. Arsenic

Source : (1) Some larvicides and rodenticides contain arsenic. (2) Arsenic is illegally used to prepare alcohol and induce abortion. (3) Factories where copper is melted, in one step of the process, arsenic is obtained as a by product. (4) Previously in many allopathic medicines arsenic was used. It is practically not used now-a-days in modern medicine. (5) In India and other parts of the world, arsenic is used in local medicines by quacks. (6) In the USA and Argentina in some rivers the amount of arsenic is higher than the permissible limit. (7) In argicultural fields to kill the herbs arsenic is used. (8) In pomphret and hilsa fish arsenic is found in greater amount than in any other fish. (9) In some regions, in some layer of the soil, arsenic may be there. Arsenic is released through some chemical process and dissolved in the water of that layer. If the tube well pumps out water from that layer, arsenic may be present above the permissible limit in that water. In certain districts of West Bengal and adjoining districts of Bangladesh water collected from several tube wells contain arsenic above permissible limit

The permissible upper limit of arsenic in water is 0.05 mg per litre.

Signs and symptoms of arsenic poisoning : If a person drinks water containing arsenic for a long time, on the skin of the abdomen, neck, shoulder, chest and back there will appear blackish grey stain like rain drops. In many cases this is the only symptom in long standing arsenic poisoning. Thereafter palms and soles of feet become thick and rough with some worty lesions, the skin sloughs, there is difficulty in standing, walking, holding, a pricking sensation in hands and feet, the sensation of touch, pain and heat is diminished. There is a general belief that cancer may also be initiated, but the possibility of skin cancer is very rare.

If arsenic is taken directly, acute poisoning effects are nausea, vomiting, loose stool, severe burning sensation in mouth and neck region, severe colicky pain in the abdomen, blood may come with the vomit. The patient may die within a few hours.

Prevention : (1) Arsenic containing larvicide and rodenticide should not be used. (2) If drinking water is drawn from the dug well or tubewell in an area, where arsenic is known to be present, the water should be tested before use. (3) If arsenic is present above tolerable limit in a tube well water, the tubewell is to be sealed. (4) Proper precaution is to be taken in copper melting industries to avoid arsenic pollution. (5) In doubtful areas, water from the new tube wells should be tested before use.

8.5.1.3. Mercury

Source : (1) Where natural gas comes out from the underground soil strata, some amount of mercury contaminates the environment. (2) During burning of coal, preparation of steel and cement and melting of metals mercury pollutes the environment. (3) In Japan, from a local factory a chemical derived from mercury (methyl mercury) contaminated. the water of the Minamata Bay, from where mercury was deposited in the body of the fishes. Many people taking these fishes became ill. (4) To destroy fungi of wheat seeds mercury-containing fungicide is used. In Iraq, in one instance those seeds were consumed by mistake and many people became sick.

Signs and symptoms of mercury poisoning : Salivation, ulcer inside the mouth, loose stool, trembling of the hands, feet, lips and tongue, lack of coordination in movement, difficulty in speech, loss of hearing, irritation, anxiety, confusion, etc. If mercury gas enters the lungs, there may be pulmonary oedema and the patient may die.

Prevention : Effluents containing mercury coming out from industrial plants and factories should not pollute the water of the river and sea. (2) Where mercury is used to kill fungi of wheat or other edible seeds, proper precaution should be taken, so that those seeds are not used for eating purposes.

8.5.1.4. Cadmium

Source : (1) From the iron ore during melting processes, lead, zinc and cadmium pollute the environment. (2) On some occasions when oil is burnt, cadmium is liberated . (3) From several factories effluents containing cadmium pollute water bodies. (4) Plastics, fluorescent dyes, antiseptic medicines, and medicines to kill fungi, etc. often contain cadmium.

Signs and symptoms of poisoning : If cadmium in gaseous and particulate forms enters the body for a very long time, toxicity may occur. It damages the lungs and kidneys. Instantaenous poisoning effect occurs when some sour food articles such as lemonade, etc. are taken from an utensil made of cadmium. The symptoms are nausea, vomiting, loose stool and weakness. The symptoms will appear within 10 minutes and subside generally within 24 hours.

Prevention : Utensils made of cadmium should not be used. (2) During melting processes of lead, zinc, etc. proper precaution should be taken. (3) Articles containing cadmium such as plastics, fluorescent dye, medicines, etc. should be used with caution.

8.5.1.5. Antimony

Source : (1) To prepare cheap enamel utensils, antimony is used. If sour food materials are kept in such utensils for a long time, toxic manifestations may occur. (2) As a medicine for malaria, antimony compounds are used. If the dose becomes high, toxicity may develop.

Signs and symptoms : These are broadly similar to arsenic poisoning.

8.5.1.6. Zinc

Toxicity may develop if zinc gets mixed with food materials and drinks in high doses. This possibility is rare. When brass utensils are manufactured, zinc oxide is liberated. If it enters the lungs, toxicity may appear with the following symptoms — fever, severe asthma, excessive salivation, headache, cough, lassitude. The symptoms disappear without any treatment and the patient usually gets cured.

8.5.1.7. Beryllium

Beryllium is used in air-craft industry and atomic power plants. From beryllium one may suffer from peptic ulcer. Tumors may also occur.

8.5.1.8. Silver

In some medicines silver used, in nasal drops silver nitrate is present. If it is used for a prolonged period blue colour is developed on the nearby skin. If silver nitrate is present in the nasal drop, it should not be used. Silver nitrate taken by mistake may cause severe poisoning with the following symptoms — nausea, vomiting, loose stool and shock. Death may occur within a few hours.

8.5.2. Biological pollution

Biological pollutants causing allergic diseases : There are some biological pollutants which are associated with immediate hypersensitivity reaction. Clinical manifestations include allergic rhinitis and bronchial asthma.

Allergic rhinitis : This is nasal inflammation. In this disorder, episodes of nasal congestion, watery nasal discharge and sneezing occur. There are two types of the disease.

(a) Seasonal — Pollens from flowers, grasses, herbs, weeds or trees are responsible when pollens enter the nasal passages, allergy occurs in some hypersensitive individuals.

(b) Throughout the year — Here the allergens are dust (from bed sheets or beds containing mites), fungi, hair or dander of animals like dogs, cats, horses, etc., feather of birds, etc.

Signs and symptoms : Sneezing, running nose, nasal obstruction, itching in the neck region, redness of eyes, water coming out from the eyes. The patient does not suffer from fever. The symptoms last for a few hours. In the perennial type, the symptoms are similar, but more continuous and generally less severe.

Prevention : (1) When pollens spread in the air in a particular season, precaution is to be taken. The patient should remain inside the room as far as possible, the doors and windows should be closed. Some sort of filter may be used to protect the nasal passage or the patient should be removed to such places where air is free from pollens. But none of the measures are practicable and effective. (2) Those who are perennial sufferers should try to identify the allergen. If it is from the dust, bed sheets and beds should be cleaned every day. Vacuum cleaner may be used. If it is from the dander of any pet animal, that pet should be removed.

Atopic or extrinsic or early onset asthma : Allergens usually enter (1) through nasal passages, such allergens are pollens, dust containing mites from quilt, mattress, bed, pillow, floor, feather of birds (some quilts contain feathers), hairs of domestic animals, fungi, etc. Much less frequently similar symptoms may be produced by (2) ingested antigens such as fish, egg, milk, yeast or wheat.

Signs and symptoms : Breathing trouble, compression in chest, temporary or permanent wheezing in the chest.

There are certain chemicals such as isocyanate gas, resin, varnish, colour, various medicines such as aspirin, penicillin, sulphonamides etc. which may be responsible for late-onset non-atopic asthma.

Pulmonary eosinophilia : A type of fungus (***Aspergillus***) can cause pulmonary eosinophilia which is known as allergic bronchopulmonary aspergillosis.

CHAPTER IX

POLLUTION AND WASTE MANAGEMENT

The topics discussed in this chapter include water pollution and waste water treatment, air pollution management at source, persistent organic pollutants and solid waste management.

9.1. Water pollution

Pure water, a chemical compound of two hydrogen atoms and one oxygen atom (H_2O), seldom exists as such in nature and is almost always contaminated to a variable extent by different physical, chemical and biological agents. Any change in the properties of water by physical, chemical and biological agents, singly or in combination, that would adversely affect the use of water for general or for specific purposes may be broadly termed as water pollution.

Table 9.1. Some sources of water pollution

Types of pollutants		*Sources*	*Effects*
(A) Particulate matters	**(a) Soil, including clay, silt, sand, gravel particles**	**Soil erosion due to deforestation, flooding, dredging, construction works etc.**	**Turbidity and blockage of light penetration, clogging etc.**
	(b) Particulate organic matters (degradable) including insects nematodes	**Solid but degradable organic debris of plants (algae, fungi leaves, twigs, straw, waste paper etc. that often float on the surface) and animals (insects, worms etc.)**	**Often emits foul odours if not degraded will clog pipelines**
	(c) Non-degradable organic matters like plastics and allied materials	**Usually synthetic household and industrial wastes, some of which could be floaters**	**Harmful to natural habitat and to the wild life**
(B) Soluble or dispersed chemicals	**(a) Fertilizer run-offs nutrients, detergents etc.**	**Run-offs from agricultural lands, domestic waste water, particularly laundry water etc.**	**Algal bloom harmful to aquatic fauna**
	(b) Chlorinated hydrocarbons	**Run-offs from crop field industrial wastes from pesticide factories etc.**	**Toxic to aquatic fauna with the possibility of biomagnification**
	(c) Petroleum hydrocarbon	**Oil-spills, industrial and urban effluents**	**Damaging to marine ecosystem, kill flora and fauna**
	(d) Heavy metals such as mercury, lead, cadmium, copper arsenic etc.	**Industrial wastes, agriculatural run-offs from pesticides-treated fields**	**Contaminate and exert harmful effects on aquatic organisms and ultimately harmful to man**
(C) Pathological organisms	**Bacteria, viruses fungi etc. (especially coliform bacteria)**	**Excreta of animals including man, domestic and hospital wastes**	**Host of water-borne diseases (dicussed in details in chapter VIII)**

Obviously, water for industrial or agricultural use may not be of the same quality as that considered safe for drinking in which besides standard physical and chemical purity, bacterial count in particular must be below a certain level. Further, even from the biological standpoint, a change in water quality may affect different organisms in different ways.

Nevertheless, in view of acute scarcity of fresh water for human use, water must be used most judiciously and waste water must be treated to regenerate fresh water to the maximum possible extent.

9.1.1. Water quality parameters

Water is an essential substance for the existence of life, but contaminated water is a threat to life and property. About one hundred and fifty years ago water was identified as a medium of propagation of many diseases. Nearly 80 percent common diseases of man are traceable to use of contaminated water. Presence in water of contaminants of industrial or municipal origin was detected long ago, large scale use of chemicals in agriculture, especially insecticides, fungicides, herbicides etc. have further aggravated the problem.

There are a number of parameters — physical, chemical and biological — that determine the level of contamination or quality of water of any kind. These parameters also determine the suitability of sample of water for a particular application or for discharge from a waste water source. The more important parameters are the following.

Suspended solids : Contaminants in water are present in both suspended and dissolved forms. Suspended solids may be inorganic (grit, clay, silt, or similar materials) or organic materials (fibres, insoluble organics, algae, bacteria etc.). Presence of such substances, some of which may be directly harmful, in water severely restricts its use. Organic materials, suspended or in solution, may degrade biologically and release harmful byproducts. Presence of bacteria in water may cause disease. Suspended solids in water is meausred by filtering a sample of water and measuring the weight of the residue dried at a prescribed temperature following standard procedures. Amount of suspended solids is expressed as milligram per litre of water.

Colour and odour : Colour may be imparted to water by dissolved or suspended materials present in water. Waste water from many industries (for example textile dyeing units, food processing industries, paper and pulp industries), laundries etc. are found to be coloured to varying extent. Coloured water is aesthetically displeasing; the colouring matters themselves may be contaminants and toxic. Organic substances may impart odour to water.

Temperature : Temperature is one of the important parameters of both natural surface water and industrial waste water. It governs to a significant extent the presence of biological species in water and their activities. It affects solubility of oxygen required for respiration of aquatic creatures.

pH : It is a parameter that indicates whether or to what extent water is acidic or basic. Clean water should have a pH very close to seven. Any appreciable change of pH from seven, either on the acidic (less than 7) or the basic (more than 7) side may have a number of adverse effects on life and property.

Metal ions : Various metal ions are found to be present in waste water depending upon its source. Ions of sodium, iron, manganese, aluminium and zinc are not toxic and are not generally harmful if these are not present in high concentrations. Chromium, cadmium, lead, mercury, arsenic, antimony, barium, cobalt etc. are toxic to varying extents. One or more of these metal ions are found in the effluents of different chemical industries, electroplating and metal-finishing industries, caustic-chlorine plants, etc. The most important technique of removing metal ions is precipitation in a highly insoluble form by using a suitable reagent.

Dissolved oxygen : Dissolved oxygen (DO) is required for respiration of aquatic organisms. The most important source of dissolved oxygen in water is atmospheric oxygen. The other important source is photosynthesis by aquatic plants and algae. Dissolved oxygen concentration in water can be measured by a DO meter or by a chemical method (such as Winkler's method).

Biochemical oxygen demand (BOD) : Organic substances in water, particularly waste water of industrial or municipal origin, are utilized as food by the microorganisms present in water for survival as well as for growth. Such organics are called biodegradable and include materials like starch, fats, proteins, alcohols, aldehydes, esters, etc., and may sometimes be the decomposition products of animal or plant origin. Microbial degradation of these materials may occur through oxidation (aerobic) or through reduction (anaerobic). In the former process, carbon dioxide (CO_2) and water (H_2O) are the end products, while the latter process yields a spectrum of products containing hydrocarbons, carbon dioxide, ammonia, hydrogen sulphide etc.

The most important effect of aerobic biodegradation of organics is lowering of dissolved oxygen level in water. Metabolism of organics by bacteria requires oxygen that comes directly from water. The dissolved oxygen concentration in water decreases as a result. The more is the concentration of biodegradable organics in water, the less will be the concentration of dissolved oxygen in it. The amount of biodegradable organics present in water is not measured directly. It is rather measured in terms of the requirement of oxygen of the microbial degradation process which is called 'Biochemical Oxygen Demand' or BOD, and is expressed as milligram of oxygen consumed for the degradation of the organics present in one litre water. Estimation of BOD in a sample of waste water is done by measuring the change in the dissolved oxygen concentration in the sample, maintained at 20°C, over a period of 5 days following standard procedures. This is called 5-day BOD.

Chemical Oxygen Demand (COD) : Organic matters present in industrial and waste water and agricultural runoffs (containing pesticides) are not all readily biodegradable or degrade slowly or by special types of bacteria. There are many organic compounds which remain in water undegraded even for years. These are stable organics many of which are hazardous as well. Typical examples are aromatic compounds (including chlorinated compounds, phenol and its derivatives), chlorinated hydrocarbons, some kinds of detergents, insecticides and pesticides. An overall estimate of the concentration of non-biodegradable substances in waste water is given in terms of 'Chemical Oxygen Demand' or COD.

9.2. Treatment of waste water

The basic objective of treatment of waste water, industrial or municipal, is to bring the quality of water to an allowable level as prescribed by the environmental laws. The components of the treatment process are as follows :

(a) removal of suspended solids, inorganic and organic;

(b) removal of biodegradable organic substances;

(c) removal of non-biodegradable, hazardous or otherwise undesirable solutes — organic or inorganic.

The conventional treatment system consists of three major operations. **'Primary treatment'** includes physical separation of suspended materials by screening, flocculation, sedimentation, floation and filtration; **'secondary treatment'** involves biological processes like removal of biodegradable organics, collodial or dissolved, biological method of removal of certain class of compounds whereby biological oxygen demand (BOD) is reduced; **'tertiary treatment'** involves physical, biological and chemical processes for the removal of nitrogenous, phosphatic and other inorganic pollutants, removal of colour, odour and removal of the remaining organic pollutants. A block diagram of a waste water treatment plant is shown in Fig. 9.1.

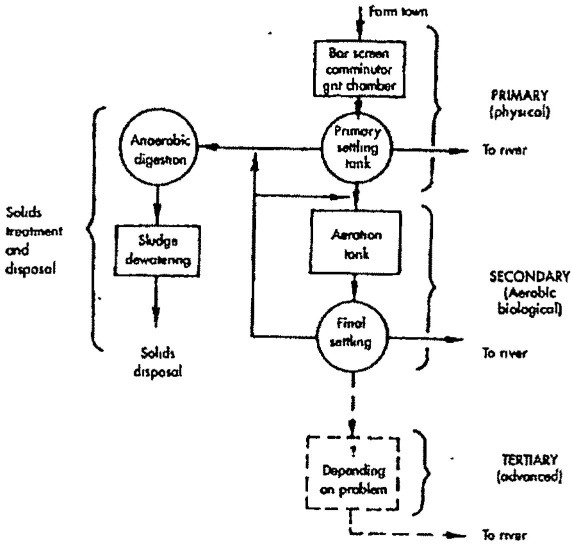


Fig. 9.1. Block diagram of a waste water treatment plant.

9.2.1. Primary treatment

Removal of suspended or floating matters is basically done by ***screening*** and ***settling.*** A wire mesh, a perforated sheet or a set of parallel steel bars placed in the flow channel of the raw waste water in a treatment plant serves as the screen and separates coarse particles. Sometimes a number of screens of gradually smaller perforation are used. The sewage then enters a widened area called the grit chamber in which the flow velocity of water decreases and most of the suspended inorganic substances like sand, small stones and grit together with adhering organic solid substances are settled.

Water free from suspended coarse solids then flows to the primary sedimentation tank or primary clarifier. This is a holding tank through which the water flows very slowly while about 50-70% of the remaining suspended solids, mainly containing biodegradable organic substances settle down in the tank. The tank may be rectangular or cylindrical provided with mechanical cleaning arrangement for periodically removing the sludge that accumulates at the bottom of the tank.

9.2.2. Secondary treatment

Removal of the remaining organics in supension and in solution in the water coming from the primary settling tank is done in the secondary treatment process. The objective is to reduce the BOD level to an acceptable limit. This is achieved by biological technique. The biodegradable organics are consumed by a broad range of bacteria present in the water. The more important techniques of secondary treatment are the ***trickling filter process*** and the ***activated sludge process.***

The trickling filter process was developed more than a hundred years ago. It essentially consists of a large circular bed of 'fist size' rocks or other coarse materials (Fig. 9.2). Waste water sprinkled on the top of the bed trickles down through the packing. The highly porous structure of the bed allows air to circulate through it because of a difference of temperature at the top and the bottom of the bed. Due to the presence of suspended and dissolved organics in the inlet

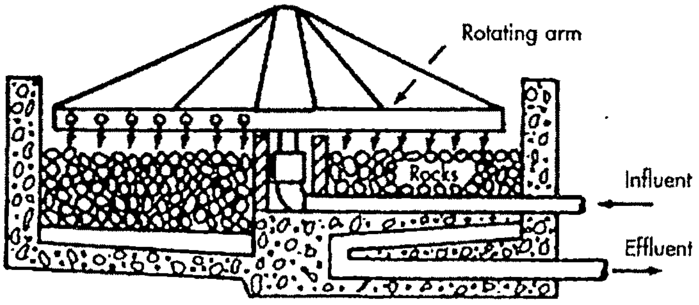


Fig. 9.2. Trickling filter

waste water, a layer of biomass grows over the packing surface. The biomass, also called slime, contains bacteria, fungi, algae, protozoa, worms, etc. that feed on the organics or BOD. The slime grows thicker with time. When the layers becomes too thick, they get partly detached from the surface and are carried by the flowing water to the bottom of the bed. The treated water accumulates in a pit below the bed and is then discharged into a receiving water body. It is to be noted that a trickling filter does no filtration. Its function is to provide a condition congenial to growth of microbes by supplying food through the downflowing water and oxygen from the upflowing air.

The activated sludge process, which is more commonly used than the trickling filters, is based on keeping a mass of microorganisms suspended in the waste water coming from the primary settling tank. This is done in the aeration tank in which air is bubbled through the water held in the tank at a high rate by a suitable aeration device. Abundant supply of the food material in the form of organics in the waste water (BOD) and of oxygen from air creates a highly favourable condition for growth of the biomass. A part of the consumed BOD supplies energy for survival of the biomass and the rest for the generation of more cells. The major end products of biodegradation are carbon dioxide and water. It takes some time for the microbes to consume the organics and reduce the BOD to an acceptable low level. After this the water leaves the aeration tank and carries with it the suspended biomass. The treated water flows to another tank in which the biomass is settled and the clear water is discharged.

The biomass left in the treated water starve for food and are active to consume more BOD and hence the name 'activated sludge'. The sludge is partly removed from the system and led to the sludge treatment unit. The remaining sludge, the returned activated sludge, is pumped back to the aeration tank where they find food in the water coming from the primary settling tank. The process operates continuously.

A large volume of sludge is formed in the primary and in the secondary treatment tanks in a waste water treatment unit. The sludge contains plenty of water (more than 95%) and mostly contains organic matters including biomass. It has to be properly treated before it can be disposed of. This is because the sludge is aesthetically displeasing, emits bad odour (because of putrefaction) and contains pathogenic bacteria. Treatment of sludge is called stabilization. The most common method of sludge stabilization is anaerobic digestion after part of the water is removed from it by dewatering in a thickening tank. This process produces substantial amount of biogas (containing methane, carbon dioxide, nitrogen etc.). Solid content of the treated sludge is increased by thickening and dewatering to get a wet, solid mass that is generally disposed of as landfill. It also has the potential of use as a manure but the presence of heavy metals has to be checked before the material is used for this purpose.

9.2.3. Tertiary treatment

The water from secondary or biological treatment may still contain some nitrogenous and phosphorus compounds and also toxic substances. Removal of these substances is done by tertiary or advanced treatment. A common technique is the use of a polishing pond or oxidation pond which is virtually a big open holding unit for the water coming from the secondary treatment. The average retention time of water in an oxidation pond is pretty long and may be even weeks. Depending upon the pollutants present, an oxidation pond have to be provided with an arrangement of aeration. Such a pond is called an aerated lagoon.

9.2.4. Industrial waste water treatment

While municipal waste water has suspended solids, BOD, COD (chemical oxygen demand) and pathogens as the principal pollutants, industrial effluents contain different types of polluting and toxic substances ranging from acids, alkalis and heavy metals on one hand to nonbiodegradable and hazardous organics on the other. Iron and steel industries, coal carbonization plants, petrochemical complexes, distilleries, caustic-chlorine plants, pulp and paper industries, pharmaceutical plants, plastics, rubber and resin industries, metal finishing industries, dye and textile industries, and chemical industries in general are major contributors of water pollution.

Acids and alkalis are found to be present in the waste water of many industires. Such water has to be neutralized before discharge in order to prevent direct and indirect damage to life and property. Integrated steel plants, metal finishing industries and paint industries emit heavy metals which have to be precipitated out. Petrochemical and many organic chemical industries discharge toxic organics, cyanides, and colouring matters some of which are not biodegradable. Special chemical methods have to be adopted for the treatment of industrial waste water. In industrial areas, common waste water treatment plants in which the waste water from a large number of units in the area can be treated at a single facility, is more economic and has been installed in some regions of the country.

The damaging effect of discharge of untreated or partially treated municipal and industrial effluents on a natural water system is exemplified by the present status of the river Hooghly. This arterial river having tremendous economic and social impact is now grossly polluted. It receives a staggering amount of BOD from the twin cities of Calcutta and Howrah — about 120 tons per day from municipal sources and 270 tons per day from industrial sources. Agricultural sources of pollution, primarily from fertilizers and pesticides, are also important. A number of sewage treatment plants were built under the Ganga Action Plan, not all of which are in operation. As a result the water quality is below the acceptable limit for many of the uses the water is put to. No full-fledged municipal sewage treatment plant exists for the city of Calcutta. An intermittently operating primary plant exists at Bantala that can treat only a part of the waste water generated in the city everyday. It is high time that proper facilities of sewage treatment is installed and operated before it is too late.

9.3. Air pollution control technology

The different methods for source reduction of formation of oxides of nitrogen and sulphur, unburnt hydrocarbons as well as particulate matters are outlined here.

9.3.1. Reduction at source of oxides of nitrogen, NO_x

Oxides of nitrogen are formed during combustion of fossil fuels in furnaces, burners and in automobile engines primarily by three mechanisms.

(i) Reaction between nitrogen and oxygen during combustion at very high temperatures of the flame. This is called 'thermal NO_x'.

(ii) A part of the nitrogen in nitrogen-bearing compounds of the fuel (coal or oil) is oxidized to NO_x. This is called 'fuel NO_x'.

(iii) The third mechanism involves reaction of the nitrogen in air with intermediate products of combustion and subsequent oxidation to NO_x. This phenomenon occurs at the root of the flame. Nitrogen oxides generated in this way is called 'prompt NO_x'.

The first two mechanisms are the major contributors of NO_x during combustion processes. Nitrogen oxides are also emitted by a several other industrial processes, the most important one being production of nitric acid.

A few techniques have been developed for the reduction of the formation of NO_x during combustion processes. The control technique that is most effective for a given fuel depends upon the dominant mechanism of NO_x formation. Natural gas is essentially free from nitrogenous compounds. So combustion of natural gas generates only thermal NO_x. But in oil firing, 'fuel NO_x' accounts for 80% of nitrogen oxides, while in the coal burning process the contribution of 'fuel NO_x' is about 50-60%, the rest being 'thermal NO_x'.

Because chemical combination of oxygen and nitrogen occurs at a very high temperature (this is why lightning produces NO_x in the atmosphere), the control techniques are based on (i) regulation of the combustion temperature, and (ii) removal of the NO_x from the flue gases by using a suitable reagent. The first method, based on combustion control, has proved to be the easiest way to implement. It reduces the peak flame temperature and lowers the thermal NO_x component. The combustion process is staged; the fuel-nitrogen is released in the first stage in a lean-oxygen zone. Additional air is supplied in the second stage to complete the combustion after the fuel nitrogen has largely combined to form molecular nitrogen. In this way it is possible to reduce NO_x emission by about 50%. Still further reduction of NO_x emission is possible by injecting a reducing agent like ammonia or urea in the combustion zone. These reagents react with NO_x to form nitrogen. The technique is called selective non-catalytic reduction (SNCR). The efficiency of the process depends upon injection of the reagent into the proper temperature zone and good mixing of the gas and the reagent (ammonia or urea).

An alternative technique is based on post-combustion control that reduces NO_x catalytically from the flue gas using the same reagents. Vanadium pentoxide is an efficient catalyst for this purpose that exhibits best performance in the temperature range 370-400°C. [$6NO + 4NH_3 \rightarrow 5N_2 + 6H_2O$]

Generation of NO_x may be brought down to as low as 20% of the normal amount by a combination of the above three processes. The techniques, individually or in combination, are very effective for industrial furnaces, for example in a power plant.

9.3.2. Reduction at source of oxides of sulphur, SO_x

Oxides of sulphur, an important contributor to the problem of acid rain, are emitted primarily by power plants, smelters of zinc and copper ores(a) and, to some extent, by chemical industries including sulphuric acid plants. Sulphur is present in coal as inorganic sulphur (mainly iron pyrites) and organic sulphur, bound to the coal matrix. The sulphur in coal is oxidized to SO_x during the combustion process. A significant part of the inorganic sulphur can be removed by washing or cleaning of coal (this is done in coal washeries) that makes it relatively free from non-carbonaceous matters before it is burnt. This, however, does not totally solve the problem. Technologies are now available to remove SO_x from the flue gases during combustion or at a later stage. Foremost among the available options is 'wet-scrubbing' of the flue gas using a slurry or suspension of powdered limestone. Oxides of sulphur, primarily sulphur dioxide (SO_2), react with limestone to form calcium sulphate (gypsum) [$CaCO_3 + SO_2 + 1/2\ O_2 \rightarrow CaSO_4 + CO_2$].

This is a proven technology and has been adopted by many power plants around the globe. The major drawback is the formation and disposal of a large amount of sludge of calcium sulphate ($CaSO_4$). An alternative effective technology is dry scrubbing of sulphur dioxide (SO_2) by directly injecting lime and limestone into the furnace. The oxides of sulphur are converted to calcium sulphate ($CaSO_4$) *in situ* and are discharged with the ash.

9.3.3. Automobile emission

Automobiles contribute significantly towards air pollution through emission of carbon monoxide (CO), unburnt hydrocarbon (HC), NO_x and, to some extent, SO_x. The problem of air pollution from automobiles is rather acute in urban areas. Provisions are made in the design of modern automobile engines for the reduction of these contaminants in the exhaust gas.

Control of nitrogen oxides is accomplished by reduction in the combustion zone temperature (see above under NO_x in section 9.3.1.) using similar principles as used for furnaces. A part of the exhaust gas is recirculated in the engine after mixing with fresh air and fuel. This causes a dilution of the fuel-air mixture in respect of oxygen concentration. The peak combustion temperature and therefore the formation of NO_x are reduced. Unfortunately, the process simultaneously increases unburnt hydrocarbon (HC) in the exhaust gas because of incomplete combustion in presence of lesser oxygen supply.

The common device for the reduction at source of HC and CO is the catalytic converter. The exhaust gas from the engine cylinder passes through a small chamber filled with a catalyst. The catalyst is a finely divided noble metal (platinum or palladium) on alumina support. A typical catalytic converter contains only about 1.5 gm of the noble metal. The carbon monoxide and

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(a) The single maximum omission of sulphur dioxide occurs from a huge copper smelter in Sudbury, Canada. The plant used to emit at an incredible rate of 2.5 million tons of the gas per year in the sixties causing widespread damage to vegetation. The present emission rate is about 365,000 tons a year.

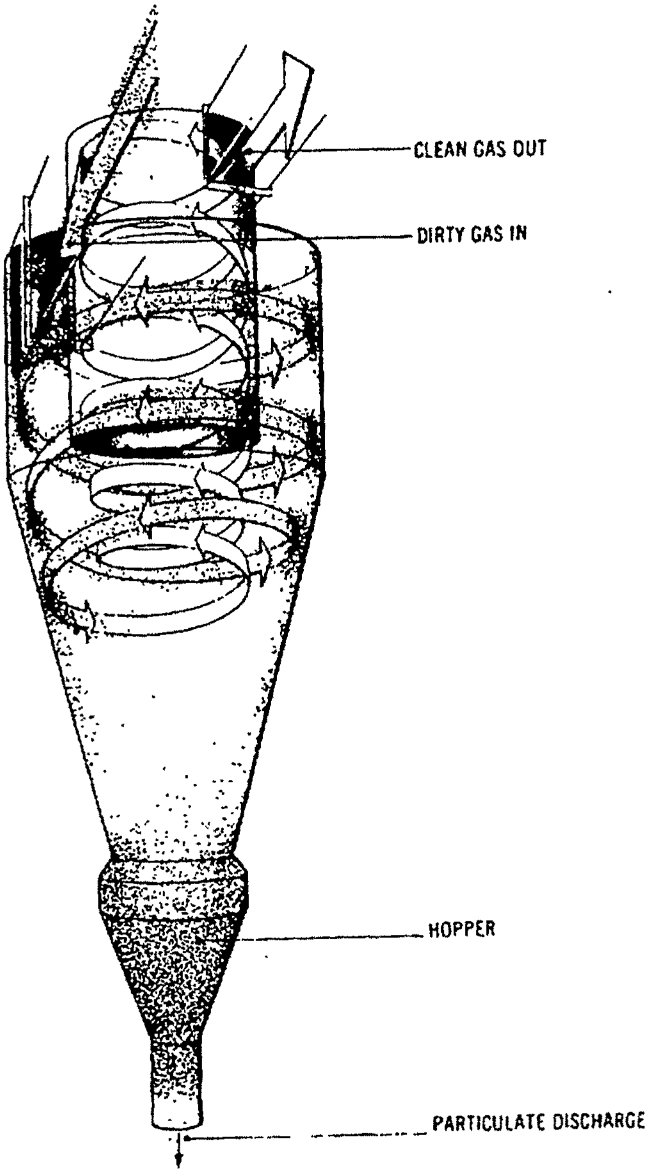

Fig. 9.3. Cyclone separator

hydrocarbons in the exhaust are oxidized to carbon dioxide and water in the converter and a relatively clean gas leaves the tail-pipe of the automobile. Performance of an engine deteriorates with time. So does that of the catalytic converter. As a result, an older car emits more contaminants and periodic monitoring is absolutely necessary to meet the emission standard.

Installation of a catalytic converter in an old car will improve emission quality. However, a catalytic converter does not work with leaded fuels because of deterioration or 'poisoning' of the catalyst.

9.3.4. Emission of mercury

Mercury is present in coal as a trace element, typically below 1 ppm. It is released during the combustion process in the form of element mercury and its compounds especially oxide, chloride or sulphate of mercury (HgO, $HgCl_2$, $HgSO_4$) and is carried away by the flue gas. Although the concentration of mercury in the flue gas remains pretty small, the total emission over the year is nevertheless significant. A survey conducted in USA reported that mercury release from power plants contribute about 50% of the total anthropogenic mercury emission. For example, a 500 megawatt power plant may cause emission of 60-120 kg mercury every year. This no doubt causes a potential hazard. Till now there is no established technology for removal of mercury from flue gases. It has been reported, however, that about 50% of the mercury (as salts) is removed during wet-scrubbing of the flue gases.

9.3.5. Particulate removal

Particulate matters are almost ubiquitous in the atmosphere. High concentrations of specific particles have been found to pose a serious threat to human health and life. Nearly all industrial and agricultural activities produce particulate pollutants.

9.3.5.1. Classes of particulate matters

Particulate matters can be broadly classified under the following categories.

Dust : This includes solid particles that are entrained in air during material handling, processing or any mechanical operation (for example, coal dust, fly ash, cement, saw dust, sand, etc). The particle size range is 0.1 to 75 micron (1 micron = one thousandth of a millimetre).

Fumes : These contain very fine solid particles formed by condensation of vapours emitted from chemical, metallurgical and other industrial processes. The particle size range is 0.03 to 0.3 micron.

Mist : This includes fine liquid droplets formed by condensation of vapours from chemical and industrial processes and have size range from 0.5 to 3 micron.

Smoke : This contains solid particles formed by incomplete combustion of carbonaceuous matters and has particle size range of 0.05 to 1 micron.

Industrial activities are major sources of virtually all kinds of particulate matters. These includes power plants, utility boilers, furnaces, smelters etc. Agricultural operations and on-road traffic also significantly contribute to particulate pollution (these are probably the most important sources of particulate pollution in rural areas). Forest fires, open burning of trash and dry leaves, wood-burning stoves etc. also contribute to particulates in air. Lead smelters emit lead oxides, copper smelters and glass melting furnaces have been reported to emit arsenious oxide besides other pollutants. Automobile emission is an important source of lead in air.

There are quite a few industries (e.g. mineral processing, coal handling, stone crushing) that emit a large quantity of particulates but often operate without proper arrangement for dust control. An extreme example is a stone crushing unit which loads air with particulates at places even two kilometres away. Several stone crushers and quarries near Delhi created severe dust pollution problem a few years ago affecting many workers and people at large and were subsequently closed down. A stone crushing unit near Jhargram, Midnapore in West Bengal, came in the headlines when dozens of workers were exposed to an alarmingly high dust concentration and fell sick. Many suffered from silocosis and died. Acting on a public interest litigation, the Supreme Court of India passed an order to pay compensation to the workers affected.

Another hazardous substance is asbestos which is used as a roofing material, for making partition walls and for thermal insulation. Very fine asbestos fibres are found to be present in the air near asbestos processing units and an exposure leads to a lung disease called asbestosis and may even cause cancer. Use of asbestos is banned in many developed countries.

Power plants that use pulverized coal in the boilers are great emitters of particulates in the form of 'fly ash' that poses a serious environmental problem. The total emission of fly ash in India is estimated to be well above 1,00,000 tons per day.

9.3.5.2. Control of particulate pollutants at source

Particulates, like other air pollutants, must be reduced or controlled at the source because once the pollutants are released and dispersed into the atmosphere, there is no way to free them from air unless these are precipitated by gravity or settled by rains or are chemically converted to other substances in the atmosphere. There are quite a few common equipment used for control of particulates at source. The more important ones are described below.

Baffled gravity settlers : A gravity settler is a long chamber through which a particulate-laden gas flows at a reduced velocity under otherwise undisturbed condition. A number of horizontal baffles are provided in the chamber. The particles settle down under gravity in the chamber as the gas flows through it. It is a simple device that may be used to collect rather larger particles of size about 100 micron or more.

Cyclone separators : A cyclone separator (Fig. 9.3) is a simple device consisting of a cylindrical upper section and a conical lower section provided with nozzles for gas flow (in and out) and for removal of the solid collected in the device. In the most common design of the cyclone, the dust-laden gas enters tangentially at the top and flows downward between the wall of the cyclone and the concentric gas outlet at the top. The gas flows in spiralling or vortex motion, reaches the bottom of the conical lower section and forms a secondary or inner vortex that moves upward and leaves through the outlet at the top. Because of the tangential velocity of the gas, the dust particles are thrown to the wall of the cyclone and then collect at the bottom. The accumulated dust is removed from the bottom.

Fabric filters : The fabric filters (the most important type is called the 'bag filter') shown in Fig. 9.4 are used to capture fine dust particles including abrasive particles, chemical dust, exhaust from furnaces, cement plants, etc. Its operating principles are similar to that of the vacuum cleaner. The basic filter element is made from a woven fabric (cotton, polyester or glass fiber) in the form of a sleeve. A large number of such sleeves or bags are kept suspended in the "bag-house" of the plant. The dust-laden gas is sucked through the bags when the dust particles are filtered and collected on the surface of the fabric. A bag filter separates almost 99% of particles of the size range from 0.5 to 5 micron. Bag filters are widely used in cement factories.

Electrostatic precipitator : The electrostatic precipitator (ESP) is used for removing a wide range of particulates including mists from gases. Even submicron particles can be removed with a high efficiency of separation. An ESP can operate at a higher temperature also. ESPs are used in power plants (for the separation of fly ash from flue gases), smelters (for zinc, copper), cement plants, blast furnaces, etc.

The working principle of an ESP lies in the creation of an extremely strong electric field by the application of a large DC voltage (20,000 to 50,000 volt) across the electrodes. The dust-laden gas passes through the region between the electrodes. In the process the particulates get charged and migrate towards the collection electrode under the action of the electric field. The accumulated dust layer keeps on building on the collection electrode and is periodically removed. An ESP has a high separation efficiency but it is a piece of expensive equipment.

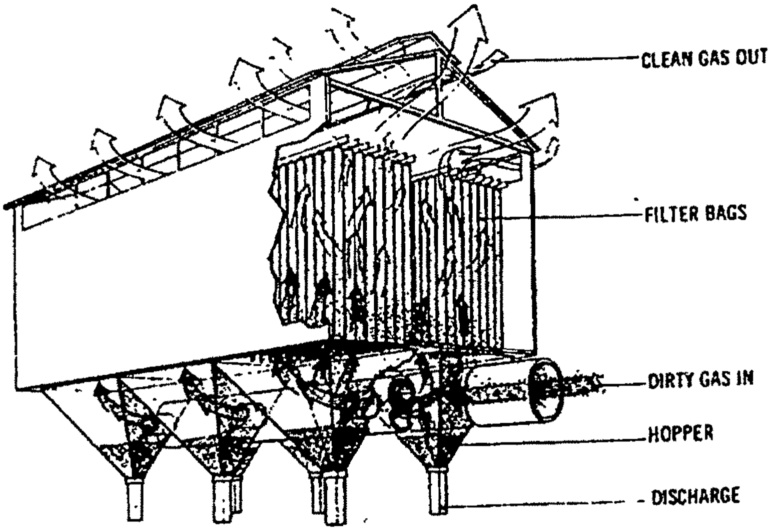

Fig. 9.4. Industrial fabric filter apparatus

9.4. Persistent organic pollutants

Persistant organic pollutants (POPs) are organic substances having a long life in the sense that these are almost non-biodegradable or very slowly biodegradable. These are released into the environment mostly as a result of various industrial and agricultural activities. It is now well established that these substances have highly toxic effects on animal reproduction, development and immunological functions and are generally carcinogenic. Among the persistent organic pollutants are twelve chemical or chemical classes that include polychlorinated biphenyls (PCB), polychlorinated dibenzo-dioxins (PCDD), polychlorinated dibenzofurans (PCDF), pesticides like DDT, chlorandane, heptachlor, hexachlorobenzene (HCB), hexachlorocyclohexane (HCH), aldrin, dieldrin, etc., and polynuclear aromatic hydrocarbons (PAH) like naphthalene, anthracene, benzypyrene etc. Some of these pesticides are either banned or of restricted use in developed countries.

Persistent organic pollutants are found to be present in sediments in rivers and lakes, soil, air and water in many places of the world. Besides they accumulate in vegetation and the uptake occurs from air, water and soil. If a compound has appreciable solubility in water, absorption occurs through the roots. Pollutants present in air are absorbed through the leaves. The lipid concentration and surface area of the leaf influence the rate of uptake. There are ample evidences of biomagnification of POPs in plants. In fact, vegetation analysis of leaf samples, particularly of pine needles, has been used to detect the presence of certain organochlor compounds (DDT, PCB, PCP, HCH) in air, water and soil in several places of Europe (this is called *organochlor fingerprint*). In fact, some plants absorb POPs to such extent that they can be used as a sink for organic pollutants. A technique based on this phenomenon, called 'phytoremediation', is now believed to have a high potential of cleaning air, water and soil from selected organic contaminants, and also inorganic contaminants like heavy metal ions.

Persistent organic pollutants, except insecticides and pesticides, are not produced intentionally but are generated in trace amounts in a number of industrial and chemical processes. For example, dioxin, a highly toxic and carcinogenic compound, is formed during incineration of municipal wastes containing chlorinated substances like polyvinyl chloride (PVC). It is also formed during production of pentachlorophenol (PCP, used as an insecticide) and chlorine bleaching of wood pulp. Total global emission of chlorinated dioxins and dibenzofurans is estimated to be a staggering 3000 kg per year. The substances get dispersed through air and water and have been traced even at places far away from the sources. An infamous case of release of dioxin occurred during the Vietnam war. The US army sprayed a formulation called Agent Orange that contained dioxin mixed with a strong herbicide, 2,4,5–T (2,4,5–trichlorophenoxy acetic acid), destroying vast stretches of forest and vegetation and inflicting dangerous effects on men and animals.

9.4.1. Biomagnification

The persistent organic pollutants are non-polar, have poor solubility in water, and most of them have very little vapour pressure. But these are lipophilic (fat-loving). In other words these compounds have high solubility in fat. If such a compound is ingested by an animal, it gets absorbed in the body fat and keeps on accumulating. When this animal (prey), having the contaminant in its body fat, is taken as food by another animal (predator), the lipophilic POP is absorbed by the predator. Repeated or regular uptake of contaminated food results in an alarmingly high concentrations of the POP in the body of the predator. This process of accumulation or gradual increase in concentration of a (toxic) substance in living tissues, mostly through food chain, is called *bioaccumulation* or *biomagnification*. This is characteristic of lipophilic substances. On the other hand hydrophilic (water soluble) contaminants (for example, organophosphorus pesticides like parathion, malathion, etc.), being soluble in water and rather insoluble in fat, are purged out through excretion or perspiration rather quickly after ingestion. As such, hydrophilic contaminants of similar toxic effects generally do less harm than lipophilic substances because the former types do not remain within the body for a long time and do not biomagnify.

Numerous cases of biomagnification of POPs have been identified and documented. As an example, the extent of biomagnification of DDT in Lake Michigan in USA may be cited as an example. Measured concentrations of DDT in the Lake Michigan ecosystem a few years ago are : bottom sediments – 0.014 ppm; bottom-feeding crustacea – 0.41 ppm; fish – 3-6 ppm; fish-eating birds – 2400 ppm. The degree of biomagnification of a POP in fish is expressed in terms of a 'bioconcentration factor' (BCF) calculated as follows.

$$\text{Bioconcentration factor (BCF)} = \frac{\text{Concentration of the contaminant in fish}}{\text{Concentration of the contaminant in water}}$$

Experimentally measured values of BCF of a few persistent organic pollutants are : DDT – 54,000; dioxin – 5,000; PCBs – 1,00,000; heptachlor – 15,700.

Hexachlorobenzenes and PCBs are termed dioxin-like compounds because of similar physiological effects. These compounds have been detected in food samples including milk. Even human breast milk has been found to contain HCB in many countries including India. Numerous cases of pesticide pollution, biomagnification and resulting effects on health and life of men and animals have been reported in our country. Pesticide pollution caused an acute fish disease in Kuttanad district in Kerala. Pesticide residues in the Chilka lake in Orissa and Kolleru lake in Andhra Pradesh have seriously affected fish and birds. In Chikmagalur, Karnataka, many people died several years ago after eating crabs containing pesticide residues.

The occurrence of biomagnification is not necessarily confined to organic substances. There are instances of bioaccumulation of heavy metals often through the food chain. For example, one source of cadmium, a toxic metal that increases the risk of heart disease, is the ash from burning coal in a power plant. Cadmium is present in coal at low concentrations (less than 0.05 ppm) but the concentration is much higher in the ash. When this ash is used for land filling or other purposes, the heavy metals in it get leached out at varying rates and are transferred to the soil and therefrom to the plants that grow on it. In this way the metal gets concentrated by three to five times that found in the ash. From the plants it gets transferred to herbivores and may eventually reach humans and other carnivores through the food-chain. The toxic metal concentration increases by 50-60 times in the process posing a hazard to health and life. Many other substances such as mercury, lead, selenium, etc. have been found to bioaccumulate.

An example of the disastrous consequences of biomagnification of mercury is what happened in the Japanese coastal town of Minamata in the fifties. It was first noticed that birds in the area flew erratically and cats went mad and were foaming at the mouth. A year or two later, a large number of people in the area, particularly fisherman, were found to have numbness of hands, feet and jaws, loss of muscular contraction, and suffered from brain damage. A large number of people died and many more became incapacitated in course of next several years. Even foetuses in the wombs were severely affected. An investigation into the cause of the disaster led to the startling fact that it was all due to mercury poisoning. A nearby chemical plant used a mercury salt as a catalyst and released mercury-contaminated effluents into the Minamata Bay. Microbial action converted the mercury to highly toxic methyl mercury that bioaccumulated in fish. People who consumed fish caught from the bay were victims of mercury poisoning.

9.5. Solid waste management

The way we manage our waste materials is a sign of our socio-economic progress. In the past, we used to throw our garbage onto the roadsides for the scavenger animals to scatter and eat. Then that was an acceptable method of handling wastes since the materials we threw were constituted almost totally of organic matters particularly kitchen and food residues. In the rural areas, the wastes used to be dumped in a corner of the household and later used as a manure along with cowdung. But with the progress of civilization and industrialization manufactured consumer goods have taken over a large share of the market. As a consequence, we have seen the advent of another kind of scavenger, the ragpickers, who collect from the wastes those materials that still have some monetary value.

Now-a-days, even in our small towns we generate hundreds of tons of waste materials — market wastes, kitchen and food wastes, hospital wastes, paper, plastics, metals and glass pieces and many other things. The average daily generation of solid wastes in the metropolitan cities of Calcutta, Delhi, Bombay and Madras amount to approximately 3000 - 5000 metric tons.

To manage this tremendous generation of wastes, careful waste management practices has therefore become urgent. Wastes may either be destroyed a reused at least in past. Man has understood that waste would indeed be a renewable resource. This renewable resource if managed well by recycling would enable us to preserve our natural nonrenewable resources unitl we need them.

9.5.1. Different management approaches

Major metropolitan areas smaller towns and cities and semiurban and rural areas have different waste management options that depend on their specific local conditions. These include practices like reduction, reuse, recycling, compost making, biofuel production (waste to energy) incineration, landfill etc.

Reduction : Generation of less wastes through efficient house-keeping, changing wasteful habits and life styles would be a positive step.

Reuse : This is the small area between avoiding waste and recycling already-used materials. A creative way to support reuse of materials is to make them available to those who can use them.

Recycling : Almost 50 percent of waste materials have been planned to be recycled in advanced countries. Paper, glass, metals, plastics, foodwast, motor oil, batteries, tyres, asphalt, car bumpers and all manner and kinds of scrap metals can be recylced. As we look at recycling as a closed loop waste management process, we realize that where ever possible we must separate at source and clean post-consumer waste product. For that we must get them at the point where they can be used and made into a new product. Finally, to close the loop it needs to be ensured that someone must buy the recycled product. All of these activities demand a behavioural change on the part of the consumers and manufacturers and necessary support from the government.

Composting : It is the biological breakdown of organic matter under airy (aerobic) conditions. Composting is seen as a major waste management option for large as well as small communities. The most common form of composting is the layering of leaves, grass and twigs and sometimes kitchen and food wastes in a compost pit or bin. This very simple technology can also be done at the municipal level. The drawback of this process is that it can generate upleasant odour and requires space sufficient enough to account for the time required for maturing of the compost and for the year-round continuation of the process to cope with the continuous generation of the wastes.

Incineration : Incineration is a process of waste management practised since 1970. For solid waste incineration with energy recovery, there are two types of waste to energy systems. One is mass burn technology which does very little to the waste materials before it reachs the furnace. The other systems is a refuse-derived fuel in which the waste is shredded before being delivered to the furnaces. The major drawbacks are ash disposal and control of emission of air pollutants.

Landfills : These are most common waste management options. Usually, three types of landfills viz. *type III, type II* and *type I*, are constructed for different types of waste materials.

Type III landfills are the least expensive to build and can accommodate construction debris and other inert materials. The more recent solid waste landfills are the *type II* ones that are usually equipped with synthetic liners, leachate collection systems, monitoring wells and in some cases methane wells to draw off the gas that collects in the landfills. The *type II landfills* are suitable for all wastes except hazardous wastes.

The hazardous wastes can only be disposed in a *type I landfill*. These landfills are constructed in a much more rigorous manner and are used primarily for contained hazardous chemicals, asbestos and other banned contaminating materials.

CHAPTER X

ENVIRONMENTAL POLICIES, MOVEMENTS AND ETHICS

10.1. History of environmental institutions and instruments

One of the major deficiencies of the studies dealing with spheres of production, such as the field and the factory, is that they ignore the natural contents in which the field and the factory are embedded. The field and the factory not only respond to the natural contents but also transform them. Ecologists, therefore, extend the sphere of production by the use of the concept of modes of resource use in order to include flora, fauna, water and mineral resources. The advantage of this concept lies in its ability to analyze institutions which govern the utilization of natural resources in different societies and historical periods. These institutions comprise forms of property, management and control, and of allocation and distribution. It is of great use in also analyzing the varying technologies of resource exploitation, conversion and transportation that are typical to different social orders.

From the broad sweep of human history ecological historians have distilled four distinct modes of resource use : a) gathering, including shifting cultivation, b) nomadic pastoralism, c) settled cultivation, and d) industry.

10.1.1. Gathering

The basic feature of this mode of resource use consisted of hunting of wild animals and the gathering of vegetable matter which provided the mainstay of subsistence. In the gathering mode, societies depended almost exclusively on human muscle power and wood fuel as sources of energy. Their material requirements were fulfilled by naturally available plants, animals and stones. Nature was viewed as whimsical, not subject to human control.

Gatherer societies encountered three distinct situations with respect to their resource base. First, their demands on the resource base were small compared to the overall availability. This is a situation resembling that of r-strategists in ecological literature, i.e. of populations that increase relatively rapidly for most of the time. The r-strategists include weedy species which rapidly colonize disturbed environments, or disease-causing micro organisms which spread in epidemics. On the other hand, societies in equilibrium with their resource base, e.g. fishing communities in an isolated coral island, are analogous to the k-strategists of ecological literature. Examples are shade-tolerant and timber-tree species in rain-forests, or microorganisms like tubercular bacilli. Finally, societies may be faced with shrinking resource base, as may have confronted gatherer societies who were displaced by advancing glaciers,or tecnologically more advanced societies.

To gatherers, nature was not subject to any human control. They regarded humans as merely part of a community of beings that included other living creatures, as well as elements of the landscape such as streams and rocks. Especially where gatherers were attached to particular localities, as in productive and stable environments like tropical humid forests, they attributed sacred qualities to individual trees, ponds or mountain peaks, or to all members of a plant or animal species, such as *Ficus* trees. They often treated plants, animals or elements of the landscape as pin, or as being in relationship of either mutualism or antagonism. Thus, rivers may be considered as mothers and totemic animals (like bears or antelopes) as brethren. Specific trees would be seen as inhabited by demons who need to be placated. Gatherers therefore entered into a whole range of mutually beneficial relationships with these other elements of their locality.

These ideologies of nature worship are strengthened by specific social practices which orient societies in the gathering mode towards the prudent use of nature. Many gatherer and shifting cultivator societies had a variety of practices which regulated their behaviour towards natural resources. These practices contributed towards ensuring the long-term sustainability of resource use.

10.1.2.Nomadic pastoralism

History of gatherer society came to an end with the domestication of plants and animals. This coincided with the withdrawal of glaciers, ten thousand years ago. It is possible that climatic and vegetational change prompted human populations to intensify resource use, and to initiate agriculture and animal husbandry. Pastorals had access to animal muscle power. It is an important additional source of energy, especially for transport. The animals also served as a source of food which could be tapped as required. In the pastoral mode, elements of private property began to emerge as lands were usually owned by separate households. However, pastures invariably remained as common property.

By surviving successfully in harsh and variable environments, and with little attachment to any particular locality, nomadic pastorals were the first societies to perceive human communities as separate from nature. The possibility of dominating nature, therefore, opened up. Such pastoral societies were unlikely to evolve strong traditions of careful or restrained resource use. Indeed, ideologies which rejected the attribution of sacred value to living creatures or to natural objects, eg. religions like Judaism, Christianity and Islam, arose in tracts that were dominated by nomadic pastorals in the Middle East. In fact such religions sometimes prescribed the deliberate destruction of sacred trees and sacred groves. In comparison with peasants and gatherers, nomadic pastorals had little need to pacify or placate nature. In the event of resource shortages they removed themselves to more resource-abundant areas — something peasants were unable to do.

Apart from these broad ideologies, in their day-to-day interaction with nature nomads did have practices which revealed a deliberate restraint on resource use. These practices included the complete exclusion of grazing pressure during certain periods within fodder reserves, and its limited use during other periods in terms of the kind and number of animals permitted for grazing — as for example in the system of *ahmias* around Taif in Saudi Arabia.

It is possible that nomadic pastorals contributed to a gradual overgrazing all through their history. They also contributed to ecological degradation through the organization of trade and diffusion of technology over large distances. They perhaps disseminated the belief in man's mastery over nature.

10.1.3. Settled cultivation

Humans learnt to cultivate plants and domesticate animals some 10,000 years ago. In some regions the two developed together with the traction power of animals and the manurial value of their dung being vital to agricultural operations. This, for instance, was the case in the Middle East, from where the use of cattle and the plough, and the cultivation of wheat and barley gradually spread over parts of Asia, Europe and Africa. In other areas, domesticated animals played a much less significant part in cultivation, as in the paddy-growing tracts of Asia. In fact, domesticated animals played no role at all in the case of maize cultivation in pre-Columbian America.

Cultivation involves an intensified prodction of certain species of plants, and the removal of plant material from a relatively restricted area of land. The plant material so removed, for instance cereal grains, are particularly rich in elements like nitrogen and phosphorus, and contains a number of micronutrients, like boron and molybdenum, in smaller quantities. The continuation of cultivation on a piece of land, therefore, depends on returning to the earth what is taken away from it. In shifting cultivation this happens through long periods of fallow. If the same piece of land is cultivated year after year, application of river silt, organic manure, or mineral fertilizers is required. Shifting cultivation is, of course, the option followed so long as the amount of land available is large relative to the population. As the ratio declines, the same peice of land has to be used more and more intensively. This calls for extensive use of organic manure derived from natural vegetation. The procurement of such manure occurred either throgh grazing domestic animals or directly by human efforts. This has changed radically only in recent times, when fossil fuel energy began to be used to efficiently mine, transport and synthesize mineral fertilizers to increase agricultural porduction.

Settled cultivation has thus depended on human muscle power, supplemented by animal muscle power. In the industrialized world, it has come to depend increasingly on fossil-fuel energy. However, pre-industrial agriculture depended primarily on plant- and animal-based materials, along with some control over water for irrigation. Consequently, pre-industrial agricultural societies had fairly substantial knowledge base in relation to husbanded plants and animals. They also viewed nature as being subject to human control to a very significant extent.

In contrast to hunter-gatherer societies,agricultural societies have established substantial control over natural processes. However, they are still very much subject to nature's whims in the form of droughts, floods, frost and plagues of locusts. Hence, agricultural societies tend to perceive man as one among a community of beings. At the same time the image of man as a steward of natural resources acquires significance. The restrained use of natural resources could thereby be expected to form one part of the ideology of agricultural societies.

10.1.4. Industry

Large-scale industry has been with us for just about two hundred years. But its ecological impact has been profound, far surpassing all that preceded this revolution. The main reason for this is the enormous jump in the use of energy with heavy demand on non-renewable resources (e.g. coal and oil), supplemented by the use of entirely novel sources such as nuclear energy. In the industrial mode energy use follows an extractive path in which natural resources are both harnessed (e.g. hydropower) and mined (e.g. fossil fuels) for human consumption. This mode has also brought about the use of a whole new range of man-made materials, e.g. metals, plastics, silicon chips and synthetic pesticides. With great improvements in transportation within the industrial mode it has been possible to transport even bulky, heavy goods like timber and rock with ease over large distances.

These abilities — materials processing, storage and transport have revolutionized flows of resources. With this a significant fraction of humanity, although still very much a minority, has come to consume vast quantities of a very wide range of resources.

The expansion of the resource base in industrial socities has rested upon access to land and natural resources which were earlier controlled by gatherer and agricultural societies. Faced with an energy and transport crisis brought about by the exhaustion of their forests, European colonists laid claim to vast terrains the world over. In his excellent book, Ecological Imperialism, Alfred W. Crosby argued that wherever the 'portmanteau biota' of these Europeans — wheat and cattle, their weeds and diseases — could establish itself comfortably as in North America, Argentina, South Africa, Australia and New Zealand, it created neo-Europes. Where the ecological setting did not permit such a takeover, as in the older civilizations of the Middle East and Asia, or in the humid tropical forests of the Amazon, the Congo and Malaysia, these Europeans nevertheless established a firm hold on the resources of these regions and organized steady outflows of what they most desired to their own lands and people. Thus, India became an exporter of teak, cotton, jute, tea, indigo and precious metals; Burma of rice and teak, the West Indies of sugar, Brazil of rubber and coffee. Although colonialism has formally come to a close, this process is still in vogue and India now exports prawns and trained manpower and tea, rather than teak and cotton. Brazil now exports beef and forest produce instead of rubber.

The feature to be noted of these resource flows is that they are highly asymmetric. Industrial societies receive large volumes of unprocessed resources at low prices and export small volumes of processed resources at much higher prices. Another implication of this process is that industrial societies produce high volumes of wastes. These are then sought to be disposed of elsewhere, either in the global commons of the oceans and the atmosphere, or through their dumping in third world countries troubled by foreign debt.

Industrial society has a totally different brand of ideology with regard to nature. It rejects the gatherer view of man as part of a community of beings and even the agriculturist's view of man as a steward of nature. Instead it is emphatically asserted that man is separate from nature, with every right to exploit natural resources to further his own well being. Nature is desacrileged. What is sacrileged is the market place. The market is supposed to be a mechanism capable of optimally allocating resources. In such a situation, it is supposed that all individuals are as well off as they could possibly be.

Industrial societies have made systematic attempts to protect their own environments. In the United States the western frontier was officially declared closed by the 1890 census. In Europe consequent to deforestation landslides occurred in the Swiss Alps in the 1860s, then the urge to take protective measures became prominently manifest. Since then Western conservationists have gradually brought back part of the forest cover of Europe (same in North America). They set in motiton an effective programme of soil conservation and set off wilderness areas. The problems of chemical pollution which surfaced after the Second World War are also being tackled with successful cleaning of the Thames, for instance. But new environmental issues have come up, such as acid rain and global warming. These require global solutions, so that it now appears as if industrial societies can no longer restrict environmental degradation to areas outside thier own borders.

Despite the aggravation of environmental problems, the ideology of industrialism has still no faith in the concern with 'physical limits to growth'. It has complete trust in technical innovation taking care of problems as they arise. It puts its faith in the efficacy of the market place to stimulate the discovery of substitutes and to enhance the efficiency of resource use. A variety of scientifically-based prescriptions on sustainable use of soils, forests, fisheries and other renewable resources has been generated over the last century and these are cited as examples of efficient resource use.

10.2. Environment policies at the national level

There has been an increasing awareness in recent years that protection of the environment is necessary for sustaining the economic and social progress of a country. This awareness was reflected at the Earth Summit held in Rio de Janeiro in June 1992. Here a global action plan called Agenda 21 was adopted with the aim of integrating environmental imperatives with developmental aspirations. It is now accepted that, in terms of natural resources, a country's demand for its sustenance should not exceed its carrying capacity. Over the last few decades, India has evolved legislations, policies and programmes for environment protection and conservation of natural resources. The Indian Government's policy has been expressed in the form of statements on forestry, on the abatement of pollution, the national conservation strategy and the policy statement on environment and development. The spirit of Agenda 21 principles has already been incorporated in these policies.

Global environmental issues, such as ozone depletion, climate change due to accumulation of Greenhouse Gases (GHGs), bio-diversity loss etc. are largely due to the rapid industrialization of the developed nations. India is, however, an insignificant contributor to the GHG emissions.

The main environmental problems in India relate to air and water pollution, degradation of common property resources, threat to biological diversity, solid waste disposal and sanitation. Increasing deforestation, industrialization, urbanization, transportation and input-intensive agriculture. These are some of the major causes of environmental problems being faced by the country. Poverty presents special problems for a heavily populated country with limited resources.

One of the objectives of the Ninth Five Year Plan is to ensure environmental sustainability of the development process through social mobilization and participation of the belief that the principal task of planning in a federal structure is to evolve a shared vision and commitment to the national objectives and development strategy. So far as environment is concerned the Ninth Plan subscribes to the belief that macro-economic stability is fundamental not only for economic growth but also for sound environmental management. The Ninth Plan envisages a multi-pronged strategy for sustainable development of the country. The important elements of this strategy are :

The discipline of forestry has been traditionally identified with either ecological stability or as a source of industrial raw material, and not with the subsistence of the rural poor. Participation of people in the management and sharing of usufruet will be achieved through Joint Forest Management which will be given priority in the schemes of the Ninth Plan. Involvement of non-government organizations (NGOs) in areas of awareness building and community education would be encouraged through various schemes during the Ninth Plan.

Environmental protection requires both preventive and curative measures. The strategy for environmental protection initiatives and interventions through policies and programmes of different sectors, notably, Health and Family Welfare, Transport, Rural Development, Energy, Agriculture, Fertilizers and Chemicals, Urban Development and Education come only as the last resort, the primary emphasis being placed on the preventive approach.

Energy sector is a major polluter. In order to minimize its adverse impact on environment a number of steps have been taken. All major power projects are subjected to an environmental impact assessment. Environmental clearance is granted to them only after stipulating appropriate environment management plans. These are rigorously monitored for compliance. A separate regulatory agency has been established for the nuclear power plants. The Ministry of Petroleum and Natural Gas has laid considerable stress on improving the quality of petroleum products, particularly, automotive fuels like motor spirit and high speed diesel.

The Ninth Plan has chalked out issue-specific programmes, area-specific programmes and sector-specific programmes. the core items of these programmes comprise : involvement of people; strengthening of the surveillance and monitoring system; preparation of state of environment reports at the all-India, state and district levels; graduation from environmental impact assessment to economic impact assessment; introduction of valuation and environmental economics and natural resource accounting.

For fulfilling the above purposes, people's involvement and role of information are essential. Mobilization and involvement of the people in environmental protection is a challenging task. Environmental protection is not the responsibility of the government alone. All sections of the society have to participate in this national endeavour. A modest step has already been taken in this regard : the notification relating to environment impact assessment has been amended and a provision has been made for the process of public hearing. All important development activities are covered by this amendment which provides that only after the issue of a Press Notification regarding the intention to set up such a project and the due process of public hearing and only after giving sufficient notice, any major activity can be undertaken. It is also significant that even under the delegation of powers to the state governments under Environmental Protection Act, the provision of public hearing is applicable. Specific schemes have been launched for involving people from all cross-sections of life from students to retired soldiers in the vast task of environmental protection. Citizens' Monitoring Committees are being established under the National River Conservation Programme.

People at large and the university system, particularly the science, engineering, and medical faculties, will be involved in monitoring and enforcement work.

Attitudinal changes are fundamental to protection of environment. Informed citizenry can play an immensely positive role in the area of abatement of pollution. If air and water resources are unfit and do not meet the acceptable standards, the people living in adjoining areas, if adequately informed, will take necessary precautions. They may also possibly organize themselves and force the responsible agencies and legislators to take appropriate action. If suitable action is not forthcoming they may, under the laws of the land, even file public interest litigation. Thus, informed citizens can achieve what even regulators and enforcing agencies cannot. Information dissemination and involvement of enlightened citizenry are fundamental to any democratic process. Information is also useful for conducting research. For instance, at present there is hardly any epidemiological research linking the levels of pollution to morbidity and mortality. Information is also a key resource which people require for getting organized and involved.

A wide network of air and water quality monitoring stations has been established under National Ambient Air Quality Management, Global Environmental Monitoring System and other programmes. This needs to be meaningfully utilized. The scope of surveillance needs to be broadened by including more technical parameters : toxic chemicals, pesticides, heavy metals etc. Bio-monitoring should also be taken up.

The use of Gross National Product (GNP) or Gross Domestic Product (GDP) alone as an indicator of human welfare and well-being is no longer considered satisfactory. It does not reflect the sustainable income of the country in the sense of flow of goods and the services that the economy could generate without reducing its productive capacity. Besides, it does not allow for the cost of damage to the environment and the resultant cost and suffering imposed on different sections of the society. The current debate is also with regard to the question as to whether a single measure of human development and welfare can be evolved or whether there should be a satellite system of accounts over and above the existing system. A number of attempts have been made for incorporation of natural resource accounts into income accounts. In order to make a beginning, an expert group under the Ministry of Planning and Programme Implementation (Department of Statistics—CSO) has been constituted for giving technical directions including finalization of the methodology to be followed for the preparation of natural resource accounting both in physical and economic terms to integrate with the State Domestic Product.

10.2.2. Environmental policy at state level (the state of West Bengal)

The Government of West Bengal is deeply concerned in matters of environmental pollution and is seriously considering the issue of environmental protection and conservation of natural resources in the state. The State Government announced its policy statement on Industrial Development in September 1994. In pursuance of this policy statement a large number of development projects will start getting implemented in the state in the near future. This will add new pressure and produce new impacts on an already overburdened environment scenario.

It is in the light of the possibility of a conflict between pro-development and pro-environment goals that the government adopted a reconciliatory approach in its policy statement. The salient features of the policy are given hereunder.

1. Activities will be intensified to control, water, air and noise pollution within permissible limits.
2. Specific environmental pollution problems created by the organized industries and in established industrial areas will be attempted to be controlled in a 10-year programme after preparation of relevant action plans.
3. Rivers, reservoirs, water bodies and watersheds in the state will be protected from encroachment, maintained and developed for ecological balance to provide for agriculture, irrigation, industrial, drinking and other civic purposes.
4. The coastal zone in the state stretching from Medinipur to the Sunderbans of about 220 km in length will be preserved, protected and restored in phase under integrated coastal zone management plans.
5. Afforestation, wasteland development, protection and enhancement of biodiversity and wild life will be accelerated, and reserved and protected forests will be enriched with qualitative genetic improvements.
6. Action plans will be prepared in phases for improving the physical environment of the cities and towns in the state in order to improve their sustainability by way of increasing their efficiency, productivity, health and reducing their risks and hazards.
7. Location of industries, urban development, other major infrastructural and civic facilities will be implemented in accordance with extant regulations and with prior assessment of environmental impacts in accordance with this policy.
8. Special emphasis will be given for water and waste management through scientific processes of demand management, recycling and reuse.

9. Importance will be given and efforts will be made to establish and encourage working relationships between government-industry, public-private, industry-academia, NGO/CBO[a]-government-private, government-media etc., in order to seek cooperation, generate increased awareness, and promote active participation in all environmental projects in the state. Various tiers of public authorities and societal organizations will be empowered to discharge specific responsibilities and obligations for this purpose.
10. Legislations and regulations relating to environmental protection and conservation of natural resources will be amended to make them simpler, more easily enforceable and more easily understood in the larger interests of the society.
11. For protection of environment, conservation of natual resources, abatement of pollution and promotion of environmental awareness, a coordination machinery among various government departments, viz. Forest, Agriculture, Irrigation, Industry, Municipal Affaris, Urban Development, Health, Public Health, Development and Planning, Transport, Rural Development, Panchayat, Science and Technology, Home, Law, Information and Cultural Affairs etc., will be set up to prepare specific action plans, achieve interdepartmental cohesion, and monitor the progress and implementation of this Policy Statement. The Environment Department will act as the nodal department for this purpose.
12. The State Government will explore all possibilities of national and international finances and commit sufficient funds for implementation of this policy.

10.3 Women and environment

For the first time 'environment' was put as an agendum of international concern in the Stockholm International Conference in 1972. After two decades, in June 1992, the United Nations Conference on Environment and Development (UNCED) was held in Rio de Janeiro, Brazil. Within these two decades, environmental concern has moved from issue to issue, and one particular issue has been the relationship of women to environment. It has been noted particularly that women who are engaged in the struggle for survival are falling victims to the growing ecological crises. Due to the fact that women are actively involved in activities of maintaining life and due to their marginalization in the process of gender division of labour, introduced and aggravated by the development processes, women have fallen victims to environmental degradation from time to time. The observation in this regard has been particularly true for the women of the third world countries.

Over the last few decades, the relationship between women and natural resources and living systems, which support the life, has changed drastically in response to heavy ecological stress in many areas of poor, developing countries. The relationship between women and

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(a) NGO – Non-Governmental Organization, CBO – Community-Based Organization.

resources has taken up a two-fold characteristic. On the one hand, women have been worst victims of ecological deterioration. There has been a sharp difference in the process of victimization by ecological stress upon women and men. The second aspect has been the beginning of the process of learning how to go beyond victimization. It is women, who are closest to the nature and hence are able to realize much better the environmental issues. Hence women can be collectivized and formed into environment protection committees, which have got the empirical evidence of working well throughout the world. When we discuss the relationship between women and nature, between women and ecology, we must keep the twin considerations in our mind.

10.3.1. Women as worst victims of environmental hazards

Why are women most affected by environmental hazards? The gender-based social and cultural responsibilities assign the tasks of collection of fuel, water, fodder and food to women and for these women have to interact with nature to a larger extent than the male counterpart. Historically women have always been protectors and managers of resources. But attention paid to their concern is too inadequate in relation to their needs and involvement. Women use and manage the life-sustaining systems of land, forests and water. They also use energy. We must take a critical look at all these aspects and how the development policies generally have ignored women in all these aspects.

Furthermore, over the years we have also realized that health and environmental issues cannot be dealt with in isolation. They are intrinsically linked with one another and neither can be easily solved through quick technological fix. Pollution today is not merely chemical; it is also biological, social and psychological. Again, deprivation of essentials viz. appropriate nutrition safe and adequate drinking water and pure air, health care, education, employment, the right to safe working and living conditions, human dignity, is in fact denial of the essentials. The impact of patriarchy and agreement of patriarchy with the socio-economic conditions have deprived the women relative to men in all these aspects.

Despite rising concerns about women's health status worldwide, there is a dearth of gender-disaggregated data in this field, on which to base appropriate policy and decision-making. Though it is increasingly understood that being female is often a precondition for deprivation, neglect and reduced access to resources and entitlements, there is hardly any data to substantiate this. Due to lower education and status, less earning power, and less access to health care, and such less obvious factors as restricted mobility, imposed through social norms and family responsibilities also frequently contribute to the victimization of women.

Local environmental conditions probably affect women more than men. Environmental degradation is creating additional pressures and increasing their workloads since their obligations and responsibilities are remaining unchanged. When natural resources are depleted, much more labour is required by women to maintain the same level of output. The workload of working and non-working children also rises, and for girls more than for boys. When pressure on women's time and energy mount, girls are more likely to be kept away from school than boys to assist with household chores. In nearly all low-income countries, both primary and secondary school enrolments are higher among males than among females. Trapped between patriarchy, poverty, and diminishing resources, it is the poor women who first and foremost pay the price of environmental destruction.

10.3.2. Women and land

Land is the foundation on which life depends. If land is healthy, then agriculture and pasturage will yield food in plenty. In developing countries, even now women are at the centre of world food production, producing more than 80% of the food in some countries. Thus, any analysis of land resources must include an appreciation of their central role.

The politics of land ownership in the entire world is such that most productive lands remain in the hands of a few. Where political power remains with the land-owning elite, access to food has become a question of social, political and economic power. Women produce more than half of world's food, yet they have title to only 1% of the world's land. In countries with food scarcity, women produce more than half of the food production.

It is women who make up the majority of subsistence farmers. There is a severe under estimation of the work done by women in agriculture. Not only they are deprived of land, but also they do all the marginal jobs related to crop raising. They supply labour, which is unpaid and recognized as marginal. They are not allowed to hold plough, but without their efforts, crops cannot be raised. In a farmer household, these jobs are mostly done as extension of household work.

Women also participate actively in cash crop production, either as extra hands in harvest time or as employees on large farms. Women sometimes spend more time in export production than men. Increasing agricultural industrialization has an enormous effect on women. It has been observed that with use of technology, there has been greater erosion, desertification, and greater concentration of land ownership, removing land from those most in need. There has also been an adverse effect on fertility of the soil. Widespread irrigation can cause waterlogging, a reduction of essential minerals, and salinization because of increased evaporation. World wide, salinization alone may require abandonment of as much land as is now under irrigation. Promoting pesticides, introduction of hybrid seeds would diminish the genetic resource base of many crops.

All of these consequences impinge upon the everyday lives of women attempting to get food, fuel and water from their environment. Many effects are confined to women because of the gender specific division of labour. Women are responsible for food processing, fuel and water gathering, and the agricultural work done by women include weeding, harvesting, irrigating, tending poultry, grazing animals or cattle, besides food preparation and marketing. The spread of erosion and desertification makes all of these tasks more difficult or even impossible. As women's contribution to their own well-being become problematic, their marginalization increases.

When access to fertile land diminishes, women are displaced to more distant, fragile and even less fertile lands, or become landless labourers. Their alienation with land grows. Without land, women have no access to credit, training or other aids to production. With the displacement of subsistence agriculture to less fertile areas, women who still have access to land must travel longer distances to their fields. When they arrive, they must work harder to compensate for severe erosion and low fertility. Growth of industrial centres in the region very often results in migration of menfolk and this means that the enormous responsibility for feeding, clothing and housing children rests soley on the women's shoulders. Thus female-headed households in poorer areas are increasing and this places more and more burden on women who are already deprived of many opportunities.

10.3.3. Women and forests

The role of women in the forest economy has been a subject of recent discussion. Trees and forests provide many rural women with their only source of personal income. When trees are rquired for food, especially fruit, it is the women who plant fruit trees in their home gardens. Trees, directly or indirectly, provide rural women with a substantial portion of their families' diet. They are often the only reliable source of food for the family, when annual crops fail. Trees are also required for fuel. Fuelling and tending the household fire has always been women's work including the hard job of collecting and transporting fuel wood. Women keep domestic animals in most societies, and trees provide them with fodder. Women also rely on the presence of trees to maintain many parts of their household. While men are usually responsible for house construction, it is nearly always the women's job to carry out minor repairs. Trees provide poles for buildings and shades, leaves for thatch, canes and stems for wattle and fibre for twine. Many of the items that women use in and around the house are made from nearby trees and shrubs that may be raised specially for that purpose. Dyes and medicine are also obtained from the plants. Small-scale forest based enterprises, such as collection and processing of raw materials into useful products, are a major source of income for the poor, and especially for rural women, including those from landless families.

Thus women perform a major part of the labour of gathering materials from the forests. Sometimes, labour is performed in a joint manner, but one cannot do without women. As income is supposed to be that of the person who does the labour, women have greater rights over the income in gathering than they have over the income from agriculture. Despite the very substantial contribution of forest dwellers in our civilization, they have never been accepted as part of the mainstream.

One can refer to the *beedi* industry as an example. The beedi is a small, cheap cigarette made from tendu leaves. The beedi industry encompasses not only those who make the thing, but also those who collect the leaves. These leaves are mostly harvested and collected by women and children. Millions of Asian women are benefiting from these, but at the expense of tremendous amount of health hazards involved in the entire process. It is the women and children, who are exposed to these health hazards throughout the process.

But the ways in which women traditionally use forest resources are becoming increasingly nonviable. There are many reasons for this to have a cumulative negative impact on the lives of rural women. First, in many areas, traditionally useful tree species are becoming increasingly scarce due to desertification and deforestation, leaving women to walk longer distances for gathering. Male migration leaves larger amount of jobs with women, with little time to carry out the lengthy business of gathering. Thirdly, new technologies are changing land use, reducing the availability of minor forest products that women have traditionally used as a source of additional income. While no alternative opportunities are open to these women, they are deprived from their old sources as well. The speed, at which deforestation and desertification is proceeding, is affecting the daily life of the women now forced to take long walks required to fetch fuel and water.

The alternatives have been to use inferior fuel, which makes cooking more difficult and time consuming. It may also cause health hazards through smoke nuisance and lessen the nutritional value of the cooked food.

10.3.4. Women and water

Women are primary water carriers, managers, end-users and family health educators. By virtue of their domestic functions, they are in constant contact with water. Women not only fetch water, but they are responsible for preparing and cooking food, cleaning utensils, washing clothes, bathing children, disposing of babies' faces and scrubbing latrines. Despite their important and multiple roles, not enough attention has been given to women as the primary users of water. Their water-related work is taken for granted and denied any economic and social value. Most women do not have enough water for daily needs; even where it is in short supply, it might be polluted and cause ill health — both for women and for their entire families and communities. Women get in contact with polluted water first, as they are primary users. Hence health hazards are making further impact on women relative to men.

10.3.5. Women and energy

In the rural sector women are responsible for the supply of energy not only for domestic consumption but for agriculture and rural industries too. Women's perspectives in energy crises need to be appreciated. It has been confirmed from studies that those women and children below five years are among the most affected due to pollutants released during the burning of bio-fuels in traditional stoves. Several health effects are observed, especially respiratory infections, chronic lung diseases, lung cancer and adverse pregnancy outcomes

10.3.6. Health and environment

For women, health issues and environmental issues are related. Stresses that were once absorbed by the ecosystem without inflicting significant damage now cause devastation. No amount of drugs and doctors can create health if essentials become scarce due to ecological erosion. Women are known to suffer from certain health problems, all directly linked to our environment. Nutritional deficiency, the most common of which is the iron deficiency anemia arising out of frequent pregnancies, childbirth and lactation, where already their nutritional reserves are low. Iodine and vitamin deficiencies compound to nutritional problems together with a systematic neglect of women' health. Early marriage, early and repeated pregnancies and the burden of household responsibilities, all take their toll. Women fall easy victims to various waterborne diseases also. Due to longer working hours, women's toil increases causing further deterioration in health as women have to walk longer distances and work harder.

10.3.7. Resource management and women

The situation with respect to deprivation of women can be improved to a large extent if women are seriously involved in the management of many environmental issues, which hit them most. In case of women, any serious thinking about their involvement is constrained by the socio-cultural biases, which always visualize women as consumers and minimize their participatory ability. But we have the instances of women's involvement in Chipko movement, which showed the way. The feelings expressed at different forums by the peasant women show their involved experience with forest and water, their perspective, struggles and aspirations for protecting and regenerating the nature.

The rural women have an integral relation with the environment. Even if they are taken as ignorant, they are able to realize environmental issues much better as they feel that these issues are not isolated. There is a linkage within the ecosystem. When the women talk about fuel, fodder crises, they also see the broader dimension of the environment in relation to the availability of water, environmental pollution caused by lack of rational use of chemicals in agriculture etc. Lack of coordination between the multiple agencies leads to the failure or low performance in projects like construction of irrigation canals, water supply, social forestry etc. The missing link in such cases as they perceive is the lack of involvement of the local people specially women, who are the prospective users of the facilities. It is necessary to consider their views in the planning and implementation of the projects.

Effective involvement of women in environmental protection means transfer of knowledge and information. It is also linked with issues such as right to land to ensure the women a legal status on land and forests, representations in the local institutions like Panchayets, municipalities and equal status of men and women in various village committees formed for carrying out developmental activities at the local level. Instructions for issuing *pattas* (ownership documents) for land in the joint names of husband and wife has been implemented in various states including West Bengal. In many cases, where afforestation programme has been taken up, the families or the women's groups involved in developing, and protecting forests share the produce on equal footing with male participatants of the programme.

Collectivization of peasant women can make them assert their rights and make their voices heard. The Forest Policy of 1988 of the Government of India saw a shift from state-controlled forest management to a decentralized and participatory management termed as "Joint Forest Management". This preserves the fundamental and age-old rights of the people to gather minor forest produce. In West Bengal we have by now a good number of women's groups who have demonstrated their ability and potential to manage the different forests. Similarly, women can be rallied around to work for the different resource management programmes. It would not have been possible if they were not organized. Then we could not have witnessed the confidence and assertion of the women from the grassroots. Peasant women, historically, have been resource managers, but this should need sufficient attention in the environment debate. The grassroots organization of peasant women should be given opportunity to not only share their view, experience and perspectives, but also to grasp the national and international dimensions of some of the critical issues. It is women who can identify the core issues affecting their livelihood as land degradation, poor maintenance of land records, deforestation, problem of water resource management, interrelationship between environment and social change, nature and role of collective action in strengthening women's voices in local decision-making processes. Besides, there is need to recover, expand and redefine women's traditional rights with greater security of tenure for resource use.

Collective control and management of productive assets like land, plantation, village forests and watersheds would increase women's bargaining power and could lead to changes in local production relations as well as power relations. In one of the action project areas of Bankura district of West Bengal, women have been mobilized around wasteland development projects. These micro-level interventions also have a snowballing effect into macro-level economic gains.

10.3.8. Impact of globalization

One of the main issues of the current phase of globalization has been the introduction of "Structural Adjustment Programmes" in the developing economies. Simultaneously with the introduction of the new policies, convergent studies point out that some human development indicators in the developing world are deteriorating. There is rising malnutrition, rising infant mortality rates, a rising proportion of high risk pregnancies, babies with very low birth weight, increased prevalence of disease, reemergence in some countries of diseases previously thought to have been eradicated, and declining educational standards. The income gap between the rich and the poor countries is widening, and the gap between the richest of the poor and the poorest of the poor is also widening.

Women are the primary health providers and the primary educators. They try to meet the health needs of the families and mould the attitudes of their children. This is so in all the countries. But in developing countries there is less help available from social services than there is in the industrialized countries, which for the most part have national health and education programmes. When as a result of the adjustment policies, government and local health and education expenditures are reduced; the first victim is the poor woman.

A growing amount of evidences suggest the following effects of adjustment policies. Indiscriminate cuts in government health expenditure lead to decline in health status of the poor population, especially women. There is a sharp deterioration in the indicators such as incidence of infectious diseases, and disease-specific mortality rates in the countries of Asia, Africa and Latin America. Secondly, a radical reduction in real food subsidies leads to an increase in malnutrition among women and children. Sharp increases in food prices, resulting from rises in producer prices or from devaluation can cause increased malnutrition among the vulnerable section of the population like women and children. Statistics on well-being of women show the double disadvantage of women and poor. In the developing countries females already have lower nutritional status and higher mortality rates, and hence they are likely to be more affected through these policies. The other effect of these adjustment policies has been informalization and casualization in the female workforce in the factories. This unprotected labour force working in the factories suffer from tremendous health hazards, which the employers completely disregard. These factories have been known commonly as sweatshops and many women are working under unhygienic conditions in such factories. The other concern in these policies have been the fact that through aid, trade and technology transfer, the control over resources has shifted from local to national and multinational agencies.

10.3.9. Chipko movement

Environmental movements like Chipko have become historical landmarks because the ecological insights and political and moral strengths of women have fueled them. It was a resurgence of woman power and ecological concern in the Garhwal Himalayas interwoven in a mosaic of various factors. The issue was of planting trees and planting ecologically appropriate trees. Women were protesting against replacement of mixed forests by the commercially valuable pine, which was a major reason for increasing economical instability of the Himalayan region and the growing economic deprivation of Garhwali women. Life-sustaining forestry was to give way to life-destroying practices. The movement showed that devolution of environmental rights and obligations is the more important aspect of environmental management.

[See section 10.5.1. for further details on Chipko Movement]

10.4. Human Rights issues relating to environment

There has been an unprecidented increase in recent years in legal claims for both human rights and environmental goods. Today legal remedies stand squarely in the centre of social movements for human and environmental protection. Environmentalists and human rights activists are working together toward common goals. Yet tensions exist between them. Environmentalists doubt the priority which human rights activists accord to human beings over other species and ecological processes. Moreover, if human rights to life, health, property, culture and decent living conditions are to be fulfilled by attainment of affluence, then a rapid depletion of natural resources is a likely consequence. In contrast, some human rights activists have criticized the environmental movements for disregarding immediate human needs in their excessive zeal to protect biota, finite natural resources and the basic needs of future generations. Hence tensions exist despite the fashionable view that human rights and environmental protection are interdependent and complementary.

The relationship between human rights and environmental protection may be conceived in two ways. First, environmental protection may be conceptually used as a means to the end of fulfilling human rights standards. It may be argued, for example, that degraded physical environment contributes to infringement of the human rights to life, health and livelihood. The creation of an effective system of environmental protection would help ensure the well-being of future generations. Secondly, the legal protection of human rights is an effective means to achieving the ends of conservation and environmental protection.

There are certain advantages of approaching environmental matters through human rights. First, mobilizing existing rights to include environmental concerns. Secondly, reinterpreting existing rights to include environmental concerns. Thirdly, creating new rights of an explicitly environmental character.

Human rights norms play an important role in environmental protection. The importance of civil and political rights lies in their ability to foster an environmentally-friendly political order. For example, the rights to life, association, expression, political participation, personal liberty, equality and legal redress etc. go a long way toward enabling activists to voice their objection to environmental damage. The converse is also true, for serious damage to the physical environment is frequently accompanied by repression of activists and denial of access to information. At the international level, the rights to life and property are well established in existing instruments and these rights should make a definite contribution to environmental protection.

While civil and political rights may contribute to environmental protection primarily through guarantees of process and participation, economic, soical and cultural rights contribute mainly through substantive standards of human well-being. Existing human rights treaties already contain provisions on the right to health, the right to decent living conditions and the right to a decent working environment. All these rights may bear directly upon environmental conditions. The right to health, for example, if approached rigorously, requires the state to take steps to protect its citizens from a poisonous environment and to provide environmental goods conducive to physical and mental well-being. Policies designed to protect humans may also protect flora, fauna and ecological processes as a consequence. For example, measures designed to guard against the radiological exposure of humans will also protect non-human species from exposure. Similarly, the right to education may help to raise environmental awareness and equip disadvantaged groups with the skills required to combat ecological damage in political fora. The violation of cultural rights, similarly, can accompany environmental degradation. So the right to participate in cultural life, if properly protected, may require the state to preserve the physical environments upon which certain cultures depend. The negative impacts of oil development operations in the rain forest on the Amazonian indigenous peoples of Ecuador, and on the

Huaorani tribe in particular, constitute a dramatic example of the direct relationship between environmental degradation and human rights violations. For the Huaorani, oil development will bring their extinction. Despite evangelization efforts by catholic missionaries and influence of oil companies, they have preserved a strong sense of identity and a significant part of their traditional culture. They remain essentially hunters and gatherers, physically dependent on nature for their survival.

10.4.1. Jurisprudence on ENV rights

India has fostered an extensive and innovative jurisprudence on environmental rights. It is now common for lawyers representing environmental claims to turn to the terminology of rights rather than the more traditional rules of tort and crime. The Supreme Court has ruled that every individual has a fundamental right to the 'enjoyment of pollution free water and air'. The Court is also willing to resolve complex matters of environmental management according to this test. In a country where the most serious costs of environmental damage fall upon impoverished and illiterate groups with limited access to courts, the new environmental right is championed as a legal gateway to speedy and inexpensive legal remedy. Since 1985, the Supreme Court and the High Courts have produced at least eighteen major decisions on environmental rights. Apart from the new rights developed by the higher judiciary since 1985, there is a large body of individual rights available in other legal forms. Thus efforts have been made in India to view environmental goods through the lens of human rights.

10.4.2. Environmental Laws

Environmental law in India primarily refers to legal rule relating to environment. It covers crime, tort, statutory regulation and fundamental rights. Each category offers considerable promise for establishing and enforcing standards for environmental management. In India, criminal law derived from the 1860 Indian Penal Code, the 1973 Code of Criminal Procedure and the criminal sanctions contained in specific environmental legislation such as the 1905 Bengal Smoke Nuisances Act, the 1980 Forest (Conservation) Act and the various Municipality Acts. The law of torts is largely uncodified and rests upon common law principles including nuisance, negligence and trespass. Statutory regulation of environmental goods began in the colonial period with forest legislations and now includes the 1974 Water (Prevention and Control of Pollution) Act, the 1980 Forest (Conservation) Act, the 1981 Air (Prevention and Control of Pollution) Act, and the 1986 Environment (Protection) Act. Taken together, these provisions amount to an extensive and sophisticated system of environmental management.

Despite the impressive legal edifice, observers frequently point out that its operation in practice does not match its promises on paper. Environmental legislation is alleged to be irrelevant to Indian circumstances. The Air, Water, and Environment Acts themsleves are not in fact comprehensive since they do not cover important environmental matters such as dams, irrigation projects and marine life. Activists point out that while the main statutory provisions relate to the control of air and water pollution, these are matters of secondary concern to local communities. The crucial environmental problem in India does not concern pollution but rather resource degradation. Resource degradation includes systemic problems of soil erosion, deforestation, declining water tables and the loss of flora and fauna.

India's environmental activists have made a real impact on polity. Conflicts over the use, management and preservation of environmental goods have given rise to hundreds of vocal campaigning organizations. Starting in the early 1970's alliances of local communities and environmental activists mounted protest that frequently succeeded in changing government policies. The Chipko tree-hugging movement, the Bhopal Gas Leak case and the Narmada Dam issue achieved the greatest international publicity. Nevertheless scores of locally-based campaigns have adopted similar tactics to good effect. It is NGO lobbying and protest, rather than governmental policy, which has provided the motive force for conservation and pollution abatement in many areas.

10.4.3.1. Green Bench

With a view to monitoring environmental problems in the states in an effective manure, the Supreme Court of India felt the need for establishing Green Benches in different High Courts in India. There was a large number of aggrieved complainants who wanted to move before judicial forum dealing with public interest litigation. This probably made the Supreme Court think that for effective monitoring and supervision of environmental problems of industries and other related matters the state level higher judicial forum would be the appropriate platform. In fact, the Supreme Court transfered tannery matters and pollution matters of 68 categories of industries to the Calcutta High Court for monitoring and passing necessary orders.

In view of such developments the Environmental Bench or Green Bench was established in the Calcutta High Court and started functioning since June, 1996 sitting at least once in a week. The number of cases dealt with by the High Court in different years since 1996 is given below

1996	83
1997	222
1998	219
1999 (up to September)	151

These cases related to various kinds of environmental problems such as :

a) Industries running without pollution control system and allegedly violating norms;

b) Illegal filling up of water bodies/tanks;

c) Cutting/felling of trees;

d) Auto-emission matters;

e) Bio-medical wastes/health hazards;

f) Dumping of garbages and non-clearance of sources;

g) Pollution generated from different morgues in the state;

h) Revival of environmental status of lakes and parks.

The Green Bench also dealt with petitions filed by the industries and other organizations and individuals aggrievied by the actions and issuance of regulatory orders of the State Pollution Control Board and other authorities like municipalities. There were also petitions before the High Court praying action on the part of the statutory authorities for restoration of the status of canals, rivers, lakes and other water bodies. Significant orders were also passed for implementation within the State of West Bengal norms controlling noise pollution generated by indiscriminate use of microphones and loudspeakers. Orders were also passed against selling and use of banned fireworks in the State of West Bengal.

Besides dealing with formal writ application, the Green Bench was also pleased to deal with environmental issues placed before it by submitting a mere application or letter by any complainant or petitioner. In most of these cases, the Bench was pleased to treat such applications as writ petition.

10.5. National environment related movements

10.5.1. The Chipko movement

The first 'Forest Act' in India was enacted in 1927. Many provisions of that Act were inimical to the interests of the tribals and the common folk living in the forests. A big rally was held to protest against such issues at Tilari in 1930. The rally ended with the murder of 17 commoners by the Royal army. In 1949, the Tehri Garhwal region constituting part of Uttar Pradesh, was annexed to the Indian federation. In remembrance of the 17 martyrs, May 30 is observed as the 'Forest Day' every year. The protests raised in 1930 gradually developed into a strong movement during the early 1970s. This movement came to be known as the 'Chipko Movement'. The word 'Chipko' means 'embracing'.

In 1961, Sarala Behn, a disciple of Mahatma Gandhi, took the initiative in forming the 'Uttarakhand Sarbodaya Mondal'. People participating in constructive social work were getting involved in the struggle for protection of forests. On May 30, 1968 a large number of tribal men and women joined the Chipko struggle. They resisted the affluent contractors and the industiralists in their act of plundering the forests. Historic marches against the indiscriminate looting of forests were organized in Uttarkashi and Gopeswar on December 12 and 15 in 1972. In April 1973, when there was an attempt to fell the trees on a dark night, the tribal women resisted by embracing the trees like their own children. Women spent sleepless nights in guarding the trees. Some notable names of those who led the movement include, Sarala Behn, Mira Behn, Gopeswar, Sundarlal Bahuguna and Chandikaprasad Bhat. In March 1974, 27 tribal women under the leadership of Gouri Devi guarded the trees for many nights at a stretch. The important call that the struggle raised was that the original species-diversity of the forests must be left undisturbed; women must have the right to collect fodder and fuel-wood from the forests. It is so gratifying to note that it was the so-called illiterate tribal women who first came forward to demand the conservation of the environment. They did not demand the forests, but only urged for the natural growth and conservation of the forest resources.

It was 1977, some forests in the tribal areas of Narendranagar were put on auction for sale. The conservationists protested strongly. The women came forward to join the protests. Leadership came from Bachhni Devi, — the wife of a contractor. Trees were being guarded day and night by rotation. An unusually popular slogan was coined : 'What do the forests bear? Soil, water and pure air'.

On 1st February 1978, the contractor who bought the forest on auction, came forward with two contingents of armed police to take up possession. The poor tribals were allured and tempted in various ways. Nevertheless, each tree was being guarded by a set of three women clinging to it. The contractor and the armed police were forced to retreat.

The assaults, however, continued and in fact were getting intensified. Sundarlal Bahuguna joined the fasting. Bahuguna was arrested on the eleventh day. Thousands of people rushed in on getting the news. The police force was compelled to retreat.

In conclusion, it is necessary to spell out, what precisely the Chipko Movement demanded? Are the forests to be left just as they are? No, the forests must not be seen only as places for plundering the natural resources. Just as forests offer teak and lac, the vegetation need to be conserved for the sake of water, soil and air. The movement only demanded the exercise of a sense of rationality in making use of the forests.

The intensity of the Chipko Movement drew the attention of the Central Government. The Prime Minister of India observed, 'not a single tree in the Himalayan ranges in Uttar Pradesh should be touched for the next fifteen years'. The message of this movement spread out from the Himalayan forests in Uttar Pradesh to the rest of the world. The 'Appico' movement in south India drew its inspiration from the 'Chipko' movement.

10.5.2. Narmada Bachao Andolan (Save Narmada movement)

The Narmada is one of the important rivers in India. It has a length of about 1450 kilometres. It flows from Amarkantak in Madhya Pradesh and after a long journey, ends up in the Arabian Sea. Ancient civilizations and cultures have taken shape over thousands of years along the banks of Narmada. The Narmada valley is inhabited by the 'Bhils' and 'Gondas,' — some of the oldest races in Indian civilization. There is a plan to build 30 major dams, 135 medium dams and 3000 small dams along the mainstream and the tributaries of this river. The mainstream will have 10 major dams. What do these plans aim to achieve? The official answer is, the dams would produce 2700 megawatt of hydel power and also supply irrigation water to 50 lakh (5 million) hectares of cultivable land. The two largest dam reservoirs are named 'Sardar Sarovar' and 'Narmada Sagar'. 'Sardar Sarovar' will be in Gujarat and 'Narmada Sagar' in Madhya Pradesh. These dams have raised protests all over the world. The names of Baba Amte and Medha Patkar have become well-known in the protest-movement lauched in India.

The protesters have raised a few basic issues. The total cost was initially estimated at Rs. 25000 crore. The amount has been escalating year by year. How can this huge cost be financed? The dams would submerge 3.5 lakh hectares of forest land. Fiftysix thousand hectares of fertile agricultural land will be destroyed. More than 10 lakh (1 million) people will become homeless. Rich and diverse forest resources will be lost. All big dams usually result in accumulation of silt.

The normal river currents get obstructed. The findings of a survey by Indian experts suggest that 75 acre-feet (9.25 ha-m) of silt will settle on every 100 square mile (259 sqkm) of the river bed near the dam. The Damodar barrage at Maithon has resulted in the deposition of 300 acre-feet (37 ha-m) of silt in place of against the estimated 75 acre-feet (9.25 ha-m). At Panchet also, the silt deposit is as high as 275 acre-feet (33.9 ha-m). The Bhakra dam project faces its greatest threat from a high deposition of silt.

Baba Amte first voiced his protests against the Narmada dams. He insisted that all details of the project cleared in 1987, must be made public. This did not happen in reality. A peaceful procession on 22nd February, 1989 was attacked by the police. About ten thousand villagers from the threatened villages in Gujarat, Madhya Pradesh and Maharashtra assembled in the rally. The administration proclaimed that if needed, the army would be deployed to suppress the movement.

Who will benefit from the Sardar Sarovar waters? There are 69 blocks in 6 districts of the Sourashtra region in Gujarat. Out of these, 56 blocks will be totally deprived of this water. Thus 81 percent of the blocks will not get any water from the dam (source : ORG, 1982 — 'Regionalisation of Narmada Command', Baroda : A Study for the Government of Gujarat). There are many similar issues on which the officials and the protesters have completely different views. The Environment and Forest Departments have estimated the loss of Rs. 30,923 crore and Rs. 8190 crore from cutting of forest trees for implementation of the Narmada Sagar and the Sardar Sarovar projects, respectively.

The construction of giant reservoirs will never be accompanied by compensatory afforestation. The issue of resettlement of the refugees will also not be considered as a priority. Rehabilitation will not be viewed in its proper perspective. The settlements, the network of livelihood and the cultural milieu woven around these over the generations will get totally lost. The "Narmada Bachao" movement has attracted international attention. Many prominent intellectuals of the country are increasingly enlisting their support to the movement. The Supreme Court, the highest judicial authority in the country, has already delivered significant judgements on quite a few issues relating to this project.

10.5.3. The Silent Valley movement

The densely-forested valley in the Palghat district of north Kerala is known as the 'Silent Valley'. It has a triangular shape. On two sides are th Kozhikode and Palghat cities in Kerala and on the other side is located the Coimbatore city in neighbouring Tamil Nadu. How did the name 'Silent Valley' originate? The forest is so deep and dark and peaceful that the slightest chirping of crickets can be heard. The general silence of the valley has given the name 'Silent Valley'. It is told that the 'Pandavas' settled in this valley after they lost their kingdom. This valley extends over 90 square kilometers. The river Kunthipura flows across the valley from north to south. 'Pura' in Malayalam means river. The river originates from a height of 2400 m. After covering 15 km of plain land, the river has abruptly narrowed down flowing along slopes about 1000 meters down. Quite long back, the state government announced the construction of a dam at the upper reach of the sloping stream. A British technical expert suggested in 1928 and 1929 that hydel power can be generated easily from this stream. The first survey on this project was carried out in 1958. The Planning Commission approved this project in 1973. The project planned to generate 120 megawatt of electricity initially and 240 megawatt subsequently. There was not much protest initially. In 1976, the project attracted the attention of some environmentalists. A task-force was formed under the leadership of the then Vice-President of the World Wild-Life Fund, India. After one year, the task-force in its survey-report, advised not to undertake the project. The report observed that the implementation of the project would result in the destruction of 'the richest expression of life that has evolved on this planet'. It, however, concluded that if the state government had no option but to go ahead with the project, the construction of the dam must comply the suggested 17-point guideline. Subsequently, in his letter of 9th October, 1979, the leader of the task-force owned his earlier proposal as a personal mistake and pleaded for a total banning of the project.

In 1976, Kerala Shastra Sahitya Parishad (KSSP), the largest popular-science organization in Kerala, engaged its serious attention on this project. A proposal to abandon the project was accepted in the State Conference of the organization and KSSP launched a mass signature campaign. Some members of the State Legislative Assembly were pressing for early implementation of the project. As a result, a resolution endorsing the project was accepted in the Legislative Assembly. The KSSP published a campaign booklet titled : "The Silent Valley Hydroelectric Project — A Techno-Economic and Socio-Political Assessment." At one point of time, the KSSP movement made the state government postpone the implementation of the project. In May 1979, Morarji Desai, the then Prime Minister of India directed the state government to expedite the completion of the project. Many environmentalists including the noted ornithologist Salim Ali voiced their objections. The International Union of Conservation of Nature and Natural Resources (IUCN) also registered its disapproval. A public interest litigation case was filed in the High Court which was, however, dismissed subsequently. A stormy debate continued in favour and against the project. In this environment related debate, even the group of politically like-minded people sharply divided themselves into two camps. Finally, in December 1980, the Kerala Government announced the scrapping of the project. The Silent Valley was declared as a National Park. KSSP has never played an anti-developmental role, it only pleaded that the usefulness or otherwise of a project be judged both from the perspectives of development and environment.

10.6. Environmental ethics : the need to develop a shared vision of a sustainable earth

Environmental problems are considered to be a matter of both national and global concern. Many of such problems impose heavy costs and not only on those close to the source of the problem but on society as a whole and on future generations. Individual countries have strong economic and social compulsion for aggressively protecting their environments by creating incentives to reduce and manage such fallouts. However, an important subset of environmental problems is global in scope. Many countries have contributed to these problems, and no individual country can effectively address them by acting alone. These are the problems of the "global commons", which will place all countries at risk if no collective action is taken. Such issues range from desertification, presistent organic pollutants to the fate of the Antarctica and the environmental health of the high seas and the seabed. Mention should be made also of issues such as ozone depletion, climate change and biodiversity protection issues which call for action on a global scale.

Effective responses to these problems are vital to the struggle for sustainable development. Climate change, for example, is likely to raise sea levels, threatening island economies and low-lying countries as the Maldives and Bangladesh. Climate change also jeopardizes agricultural production in developing countries. The Russian Federation and parts of Africa could see dramatic reduction in their crop yields by 2050 AD. The overall impact of a doubling of carbon dioxide in the atmosphere would be to reduce the gross domestic product (GDP) of developing countries by an estimated 2 to 9 percent, compared with 1 to 1.5 percent of GDP in industrial economies.

Despite the urgency and importance of environmental issues, building cooperation to address global environmental problems is not simple. It involves contentious issues such as the division of responsibilities and differing capabilities to respond. Industrial countries have created many of the international environmental problems. In the pursuit of economic advance, they have destroyed much of their biodiversity and have overexploited fisheries worldwide. They also have the highest level of energy use and thus bear the overwhelming responsibility for the present level of man-made green house gases in the atmosphere. At the same time, developing countries are unlikely to become actively involved in addressing global environmental problems if the price is slower economic progress. The United Nations Framework Convention on Climate Change and the Convention on Biological Diversity specifically recognized that economic and social development and poverty eradication are overriding priorities of the developing countries. It follows that there is a strong need for transfer of resources from rich to poor countries in order to solve global environmental problems.

Even though industrial countries have played a disproportionately large role in causing global environmental problems and should pay the lion's share of the costs of addressing them, developing countries are vital to any long-term solution to these problems and have accepted that they also have a role, under a system of common and differentiated responsibilities. Developing countries are already doing damage to the global commons. Rainforests and coral reefs are rapidly destroyed in many developing countries. Urbanization, industrialization and growing number of automobiles worldwide mean yet more green house gases in the atmosphere. Overfishing has spread to seas controlled by developing countries. Both developed and developing countries have a stake in the global commons and, therefore, both have a strong interest in ensuring that cooperative steps are taken to address these issues. The cooperative spirit is manifest in the efforts now being made to tackle global environmental problems in a multinational framework. Since the 1972 Stockholm Conference on the Human Environment, governments have signed more than 130 environmental treaties, with increasingly substantive regulatory provisions. These treaties have contributed to many positive developments.

Glossary

of

Common Environment-Related Terms

Terms selected from the text of an environmental dictionary prepared by the Editor

GLOSSARY

A

ABIOTIC : A situation or phenomenon that is characterized by the absence of living organism.

ACCLIMATIZATION : The process by which an organism is able to adapt to a new condition as imposed by edaphic (relating to soil), climatic and other environmental factors.

ACID RAIN : Rain water containing a level of acidity higher than normal, usually weak acidity is due to dissolution of carbon dioxide in rain water. The relatively high acidity of rain water is due primarily to the presence of oxides of sulphur and nitrogen (produced during burning of fossil fuels in automobiles and industrial set ups) in the air and their dissolution in the falling rain drops (generally forming sulphuric and nitric acids); usually acid rains occur far away from the places of origin of the gases as the gases are carried in the wind-drift to quite distant places.

ADAPTATION: The act of adjustment by an organism to environmental conditions through modifications of organs if necessary.

AEROBIOSIS : Life in the presence of air (oxygen) in contrast to anaerobiosis where life thrives in the absence of oxygen.

AEROSOL : Fine liquid, solid or gas particulates that remain suspended in the atmosphere for varying periods; small containers of liquid with a propellant under pressure for spraying of pesticides, cosmetics, etc.

AFFORESTATION : Establishment of a forest cover on land; planting trees on land that was previously used for other purposes or raising a new forest after felling and clearing of an old forest.

AGENDA 21 : Document outlining the extent of global environmental problems and measures to control the same prepared and agreed upon at the UN Conference on Environment and Development (UNCED) Summit at Rio de Janeiro, Brazil in June 1992.

AGENT ORANGE : The code name for the herbicidal preparation used by the U.S. Army in the Veitnam War for clearing jungles to locate guerrillas and for destroying food crops to starve the people containing nearly equal parts of 2, 4-D (2, 4-dichlorophenoxyacetic acid) and 2,4,5-T (2,4,5-trichlorophenoxyacetic acid) with traces of extremely toxic TCDD (2, 3, 5, 7-tetrachlorodibenzo-*p*-dioxin) as contaminant of 2, 4, 5-T.

AGROCHEMICALS (Syn : AGRICHEMICALS) : Chemicals used in agriculture including fertilizers, pre- and post-emergence herbicides, fungicides, insecticides, nematocides, hormonal chemicals etc.

AIR : The invisible layer of odourless and tasteless mixuitre of gases which surrounds the earth all throughout as a most essential cover, primarily restricted to 20 km above the sea level, and that has been responsible for the sustenance and evolution of most forms of life. The air is primarily composed of nitrogen (78%) and oxygen (21%) but other gases such as carbon dioxide (0.035%), water vapour (variable 0-4%), ozone (0.00006%) all have very important specific constitutional and regulatory roles; without air the earth would have been a barren land.

AIRBORNE POLLUTANTS : Pollution-causing substances carried away by air from the source to other places, eg. smoke from tall chimneys of factories, gaseous pollutants, fly ash, dust, fine fibres etc. are carried to other places depending on the direction of wind.

AIR POLLUTION : Any man-made or natural change in the normal composition of air, changing the concentration of one or more relative to the other gases (such as increased carbon dioxide concentration with associated long term effect on global warming) or adding newer ones (such as emission of oxides of sulphur and nitrogen — the precursors of acid rain, release of health damaging foul gases, production and release of ozone-depleting chlorofluorocarbons thereby allowing greater penetration of harmful uv-rays), or through release of fine suspended particulate matters (such as generation of excessive quantities of fly ash, fine silica particles, minute textile and asbestos fibres that precipitate serious respiratory diseases) through various industrial and allied activities — all with adverse short-and long-term effects on the ecosystem and biosphere.

ALBEDO : Earth's reflectivity; ability of a source to reflect light (reflective power); as such, albedo is high for light shiny surfaces and is measured by the proportion of incident light that is reflected by a surface or a body (such as the moon or cloud); expressed in percent values, albedo of land surfaces would generally range from 15 to 30%, oceans 10-20% and snow 70-90%.

ALTERNATIVE ENERGY : Usually nonconventional energy sources such as solar, wind, geothermal, tidal etc. are termed as alternative sources.

ANAEROBIOSIS : Life in the absence of oxygen; anaerobic respiration such as alcoholic fermentation.

ANOPHELES (a MOSQUITO) : Malarial parasite-carrying mosquito; the female *Anopheles* mosquito is responsible for malaria disease caused through transmission (during bite and blood sucking) of the sporozoan parasite of the genus *Plasmodium* into the red blood cells.

ANTARCTICA : The continental landmass measuring 13.8 million sq km around the South Pole usually delineated by the antarctic circle — a small circle of the earth parallel to the equator approximately 23°27′ from the South Pole, it is the world's fifth largest continent nearly 98 percent of which is covered by snow and ice upto an average depth of 2 km.

ANTHRACITE : A superior type of hard coal with a high carbon content and a shiny appearance, and which burns giving little smoke.

ANTHRACOSIS : A disease of the lungs caused by inhalation of coal dust produced during mining, coal crushing and processing.

ANTHROPOCENTRIC : Regarding man as the most significant entity in the universe, the anthropocentric views would consider components of the natural world to be valuable only as the means to some human end.

ANTHROPOGENIC ACTIVITY : Action relating to or involving the impact of man on nature, anthropogenic changes in the natural world may be good or bad — afforestation of denuded areas, preservation of wetlands, preservation of biodiveristy and especially saving endangered flora and fauna, recycling of wastes are some positive anthropogenic activities while emission of pollutants, acid rain, global warming, unregulated deforestation, oil spills, excessive consumerism, population explosion are some of the darker areas of anthropogenic changes that have far-reaching effects on the life-support systems of the earth.

ANTICAKING ADDITIVE : A substance added to food to prevent it from becoming solid.

ANTIKNOCK ADDITIVE : A substance added to a fuel to prevent knocking in an internal combustion engine, eg. tetraethyl lead (or tetramethyl lead) added to petrol.

AQUACULTURE : Rearing in water of aquatic plants, fish and shellfish for food either in special structures or special ponds, or employing specific devices in certain parts of lakes or seas; also known as aquafarming.

AQUIFER : Water-bearing stratum of porous rock, gravel, sand or soil; water accumulates in the layer and passes into wells and other structures built for collection of underground water.

ARSENIC POLLUTION : Arsenic is a highly poisonous metalloid (four times more poisonous than mercury) and arsenic compounds have been routinely used as poison baits especially for rodents. Recently, arsenic pollution of water in many districts of West Bengal (even greater areas in adjoining Bangladesh) due to release of mineral-bound arsenic in the ground water (especially in tubewell lift areas) has become a matter of serious concern. Prolonged use of ground water containing over 0.05 mg arsenic per litre of water for drinking may give rise to arsenicosis (which has been reported from many countries) with symptoms such as melanosis and keratonosis of skin, gastroenteritis followed by liver and kidney disorders and even cancer of skin, bladder, lungs etc. Precautionary steps are therefore essential to avert a major public health crisis.

ASBESTOSIS : A disease of the lungs and respiratory tract (pneumoconiosis) caused by inhalation of fine asbestos particles; asbestos dust can cause some forms of lung cancer, blue asbestos (one form of asbestos) is banned in some countries because of high toxicity.

AUDIOMETER : Instrument used to measure the sharpness of hearing; audiogram is the graph drawn by an audiometer.

AUTOTROPH (Syn : AUTOTROPHIC ORGANISM) : An organism that needs a source of carbon usually carbon dioxide (also often carbonates or biocarbonates) for synthesis of its food (usually carbohydrates) and simple inorganic nitrogen for proteins etc., and do not require exogenous supply of organic food or nutrients for sustenance as exemplified by chlorophyllous green plants which use the energy of sunlight in photosynthesis for carbon-carbon bond formation; chemautotrophic bacteria get the necessary energy from the oxidation of inorganic substances such as sulphur, iron, ammonium nitrate etc. for bonding of carbon atoms in a process known as chemosynthesis.

AZOTOBACTER (AZOBACTER) : Rod shaped or spherical soil bacteria belonging to the genus *Azotobacter* that are capable of fixing free nitrogen of the air into nitrogenous compounds.

B

BHC : 1, 2, 3, 4, 5, 6-Hexachloro cyclobenzene, incorrectly but commonly and popularly known as benzene hexachloride, (lindane, gammexane) — an organochlorine insecticide, (and parasiticide for ectoparasites) — human toxicity and poisoning may occur by ingestion, inhalation or percutaneous (through skin) absorption.

BHOPAL GAS TRAGEDY : The world's most tragic industrial disaster took place in the midnight of December 3, 1984 when 36 tons of highly toxic methyl isocyanate (MIC) gas (used in the production of the insecticide sevin) leaked out of the storage tanks of the factory of the multinational company, Union Carbide, at Bhopal killing as per official records 2300 persons (unofficially over 10,000) and injuring to various degrees nearly half a million people. Lack of foresight, negligence on the part of the management and failure to take adequate precautionary steps were the major reasons of this man-made tragedy.

BIOACCUMULATION : The progressive accumulation over time of toxic components of pesticides and other chemicals and metals through the food chain; also known as biomagnification.

BIODEGRADATION : Breakdown of substances by bacterial activity; nonbiodegradable substances are environmentally less friendly.

BIODIVERSITY : The wide range and richness of the living world as manifested by the vast generic and specific distribution of flora and fauna giving rise to the large qualitative and quantitative differences in the living organisms.

BIOGAS : Usually methane (CH_4) gas (commonly mixed with carbon dioxide) produced through fermentation of farm wastes particularly excreta of farm animals; eg. gobar gas from cowdung.

BIOLOGICAL OXYGEN DEMAND (BOD) : A measure of requirement of oxygen for microbial degradation of organic matter present in water and is expressed as milligram of oxygen consumed for the biological degradation of organic matter present in one litre of water.

BIOMAGNIFICATION : Progressive increase in concentration of certain substances in the body over a long period because of passage through the food chain.

BIOME : Geographically large ecological region characterized by broad similarity in vegetation and climate, the principal biomes of the world are the tundra, temperate coniferous forest, temperate deciduous forest, tropical rain forest, temperate grassland, tropical savanna and desert. A particular biome may often be present in different continents of the world but those regions do have a broad similarity in climate, topography and soils which is reflected on the vegetation in particular and other organisms in general.

BIOSPHERE : All the parts of the earth's lithosphere, hydrosphere, atmosphere that (the parts) taken as a whole, accommodates the living organisms.

BIOTIC PYRAMID : A graphical representation of producer-consumer involvement in the food chain, with the primary producer at the base of the pyramid and the topmost predator at the top, living on lower level carnivores or herbivores — the latter (the herbivores) occupying the position just above the primary producer (green plants).

BOVINE SPONGIFORM ENCEPHALOPATHY (BSE) (Syn : MAD COW DISEASE) : A fatal virus disease of cattle reported from U.K., that affects the central nervous system and spreads to man through consumption of contaminated beef.

BUILT-UP AREA : An area full of houses, shops, offices etc. specially built for urban or semiurban living and related purposes.

BYSSINOSIS (Syn : PNEUMOCONIOSIS) : A kind of lung disease (pneumoconiosis) caused by inhaling cotton dust in cotton textile industry.

C

CANCER : A malignant tumerous growth beyond the usual control mechanism of the body and spread by metastasis via blood stream or lymph system.

CARBON MONOXIDE (CO) : A colourless and odourless gas produced in incomplete oxidation of carbon and highly toxic to the living system.

CARCINOGEN : A substance or an agent that may produce cancer or incite cancerous growth.

CARCINOMA : A malignant tumor of epithelial tissue (membranous cellular tissue covering a free surface).

CARNIVORE : (Syn : CARNIVOROUS ANIMAL) : A flesh-eating animal.

CARRYING CAPACITY : The maximum number of a species that can be accommodated in a given area, usually calculated as the number of individuals of a species per square kilometre. For man also, the term carrying capacity refers to the maximum number of persons that can be sustained per sq km of area.

CELL : The basic unit of life composed of membrane-bound protoplasmic structure that contains the all-important nucleus (the controlling authority of the cell) in a bed of cytoplasm which with the help of a range of bioorganelles and molecules carry out the life-functions under the overall supervision of the nucleus. The nucleus is generally the seat of chromosomes in which the genes — the units of heredity, chemically identified as deoxyribonucleic acids (DNA molecules), are located. Unicellular microorganisms (bacteria, protozoa, certain algae and fungi) consist of a single cell but multicellular organisms may contain millions or even billions of cells.

CHAIN REACTION : A series of reactions occurring in such a way that each reaction initiates the succeeding one; in nuclear chain reaction, each reaction may yield energy or products that initiate further similar reactions so as to become self-sustaining.

CHEMICAL OXYGEN DEMAND (COD) : A measure of the concentration of nonbiodegradable substances dissolved in water, expressed as milligram of oxygen consumed for chemical oxidation of the nonbiodegradable substances present in one litre of water.

CHEMICAL RESIDUE : The waste products left after the completion of a chemical industrial process; a chemical residue left in a plant, animal or product after application of a pesticidal chemical substance.

CHEMICAL WARFARE/CHEMICAL WEAPON : A war in which toxic poisonous chemicals are used as weapons of destruction such as mustard gas, a highly irritating blister-causing oily liquid [$(CH_2CHCl)_2S$], nerve-gas, or herbicides like Agent Orange used by the American forces in the Vietnam War to destroy forest and field crops (TCDD, one of the deadliest poisonous chemicals known to man had been present as a contaminant in Agent Orange).

CHERNOBYL : A place in Ukraine in the erstwhile USSR where a devastating accident in the nuclear power station in April 1986 scattered nuclear debris over a wide area covering the east European countries and part of Scandinavia.

CHIPKO ANDOLAN (TREE-HUGGING MOVEMENT) : An extraordinary environmental movement initiated in the early 1970s to prevent large scale ecologically damaging deforestation in the Himalayan foot hills of Tehri-Garhwal in UP. Village women were organized into unique resistance groups who literally held the trees in embrace (2-3 women per tree) for days and nights preventing commercial loggers to fell them. Nothing could dislodge these determined women and despite all efforts the local administration failed to implement logging for which permits were issued to contractors. Ultimately, the provincial as well as the government at the centre had to announce a stoppage of tree felling in Tehri-Garhwal.

CHLOROFLUOROCARBONS (CFCs) : Gaseous compounds made up of carbon, fluorine and chlorine widely used as refrigerant of refrigerators and air coolers, in production of plastic foams, propellant for aerosol cans and cleansing agent of circuit boards of computers; CFCs are held responsible for stratospheric ozone depletion.

CHLOROPHYLL : The green photosynthetic pigment of plants found in chloroplasts; usually present in two forms — chlorophyll 'a' and chlorophyll 'b' with the formula $C_{55}H_{72}MgN_4O_5$ and $C_{55}H_{70}MgN_4O_6$ respectively.

CHROMOSOME : Thread-like nucleoprotein structures in the nucleus of cells that take up basic dyes and become darkly stained; genes (DNA macromolecules) are located on the chromosomes usually arranged in a linear fashion. Chromosome number in a species is usually fixed and retained over generations.

CHRONIC EVENT : An event marked by a long duration or frequent recurrence; especially used for long-lasting or recurring disease.

CLOUD : Visible mass of water vapour or fine ice particles that remain suspended or float high in the air with the potential to condense and precipitate in the form of heavy to light or no rains depending on its kind and prevailing atmospheric conditions; clouds are of a number of types such as cirrus, cirrostratus, cirrocumulus, altostratus, altocumulus, stratocumulus, nimbostratus, cumulus, cumulonimbus and stratus.

COAL : Solid black carbon-rich substance originating millions of years ago from decaying plants which initially formed peat and then under pressure from subsequent deposits were converted to various grades of coal of varying hardness and quality; anthracite is the hardest and best followed in order by bituminous coal and lignite; the same is true for quality and fuel efficiency.

COGENERATION : Production or generation of two or more things at a time such as heat and power generation in a combined heat and power installation.

COLIFORM BACTERIA : Bacteria that resemble the colon bacillus, similar in shape to *Escherichia coli.*

CONGENITAL DEFECT : A defect which existed before birth; genetic defects are all congenital defects.

CONVENTIONAL ENERGY/FUEL SOURCES : Usually traditional energy sources such as coal, wood, petroleum, natural gas etc; solar, tidal, wind power etc. are nonconventional sources of energy.

COST-BENEFIT ANALYSIS : An analysis, in economic terms, of the advantages and disadvantages of a course of action; the total economic and social returns against the expenditure.

CYCLONE : A kind of tropical strom in which the wind rotates around a centre of low atmospheric pressure anticlockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere with wind speed reaching 100 km per hour or more; in anticyclone the wind circulates round an area of high pressure clockwise in the Northern Hemisphere and anticlockwise in the Southern Hemisphere.

D

DECIBEL : One tenth of a "bel" — the unit of sound intensity, abbreviated as dB. Mathematically, $dB = 10 \log_{10} I/I_0$, where I is the intensity of any sound and I_0 is the intensity of a reference sound of the same frequency just audible to the average human ear. The audibility of human ear ordinarily ranges from 0 to 130 dB with the faintest perceptible sound taken as one decibel (1dB).

DDT : Dichloro-diphenyl-trichloroethane, a very potent organochlorine insecticide but a major disadvantage is large bioaccumulation and magnification through food-chain. Presently not recommended (banned in the USA since 1973) because of persistence and bioaccumulation (gradual build up in the food via insect → small predatory animal → bigger predatory animal) leading to the detection of DDT or its stable breakdown products DDD or DDE. Further, many insects have acquired resistance against DDT.

DEEP ECOLOGY : An ecological thinking of extreme form in which no particular importance is given to man, and man is considered just as one of the many species living on earth and whose growing number is considered ecologically disastrous.

DEFOLIANT : A chemical herbicidal substance used for removal of leaves of standing plants; Agent Orange, a mixture of two herbicides 2, 4-D and 2, 4, 5-T, was extensively used as a defoliant by the US Army in the Vietnam War to clear jungles.

DEFORESTATION : Clearing of forests, cutting down (clear felling) of standing trees.

DEMOGRAPHY : A branch of human geography that deals with various aspects of human population.

DESERTIFICATION : The process by which a tract of land turns arid and then becomes a desert due to a change in climate or through deforestation, excessive grazing, soil erosion etc.

DEW : Moisture of humid air that condenses at night on surfaces of cool bodies in the form of small droplets.

DIOXIN : A highly poisonous chemical, 2, 3, 7, 8-tetra chlorodibenzo-*p*-dioxin produced in very small quantities as a byproduct during the manufacture of 2, 4, 5-T, a herbicide and in a number of other chemical industries.

DISSOLVED OXYGEN (DO) : Molecules of oxygen that are dissolved in water, support respiration of aquatic organisms.

DOM (DIGESTIBLE ORGANIC MATTER) : The portion of organic matter that can be digested and broken down.

DOMINANT SPECIES : A species of plant or animal that would have the most significant influence on the composition, number and distribution of other species of flora and fauna.

E

EARTH : It is a planet of the sun (a star of the Milky Way galaxy of the universe) and third in order of distance from the sun and revolves round the sun in nearly circular orbit, with its natural satellite the moon, in approximately 365 days. The medium-sized sun-nourished planet, having a mass of 5.98×10^{24} kg and an equatorial radius of 6387 km, has provided through the geological ages a congenial environment for origin and evolution of life and natural ecosystems favouring a rich diversity of species, capable of sustenance through mutual interactions, unless disturbed by natural geoclimatological or anthropogenic events.

EARTHQUAKE : The shaking and trembling of the earth due to movement inside the lithosphere that could be tectonic or volcanic in origin. The intensity of the earthquake is measured in the Richter scale (after Charles Richter) with values ranging from 0 to 10 (logarithmic scale), scale values above 5 would cause damage; the values taper off with increasing distance from the epicentre (the surface of the earth above the focus of the quake).

EARTH SUMMIT : The high level intergovernmental meeting on environment of the earth held in Rio de Janeiro, Brazil in June 1992, namely "United Nations Conference on Environment and Development" abbreviated as UNCED but popularly known as Earth Summit. The points of broad agreement reached at the meeting have been circulated as the Rio Declaration.

ECOLOGICAL BALANCE : A more or less stable state in which the numbers of different organisms in a natural habitat have reached a steady level and remain nearly the same over time.

ECOLOGICAL NICHE : A habitat in an ecosystem that supplies all the requirements and factors for the existence and survival of an organism or a species.

ECOLOGICAL PYRAMID : A graphic representation of the structure of an ecosystem in which the producers (plants, many in number, large biomass) are at the base, the plant eaters (herbivores) are at the middle and the carnivores (fewer in number, smaller total biomass) are at the top. The ecological pyramid is synonymous with biological pyramid and could be based on numbers of organisms, total biomass of the groups of organisms or on the energy at each level.

ECOLOGICAL SUCCESSION : Stages or steps in a community leading to the climax — the stable state.

ECOMOVEMENT : Organized movements by environmentalists and people concerned with environmental degradation to protect the environment from further deterioration and to take steps for restoration and conservation.

ECOSYSTEM : A complex mutually interacting assemblage of a group of coexisting organisms that interact with the environment forming a functioning whole in nature, the size of such a system may vary from a very small one to a vast geographical area.

EFFLUENT : Something that flows out; in pollution control, the term usually refers to liquid household and industrial wastes (often applied to gaseous pollutants as well).

El NINO : A climatic phenomenon occurring every few years (usually two to five years) in the Pacific Ocean where a mass of warm water moves along the Pacific Coast of South America rising and moving with high tides and rains. El Nino is believed to influence climatic and rainfall patterns all around the Pacific basin with high rainfalls in the Pacific Coast of South America and South India but making Australia and North India drier. El Nino brings about complex interactions of ocean currents and atmosphere with resultant meteorological anomalies such as shifting precipitation belts, unusually high rainfall or stormy weather or poor rainfall and drought etc.

ENVIRONMENT : The term literally means "something that environs" (encircles, surrounds or covers up); as such, it includes the overall effect of the surroundings on an organism, groups of organisms or an ecological community implicating thereby highly complex interactions of climatic, edaphic and biotic factors on the liveliness, sustenance and finally survival of the organism and other members of the community.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) : A comprehensive and critical assessment and evaluation of the short and long term consequences of a big construction programme or a development project on the environment on the basis of evidences and experiences as available locally and globally for similar activities.

ENVIRONMENT-FRIENDLY (ECOFRIENDLY) : Any activity or activities and actions which do not harm the environment; any thing that helps protecting the environment.

ETHICS : Principles (code) of conduct based on moral values for individuals and groups especially professionals as to what is good and what is bad, and what should be done and what should not be, keeping in view, the interest of mankind and biosphere as a whole.

EVAPOTRANSPIRATION : The loss of water from soil by evaporation as well as transpiration by plants growing on the soil or waterbodies.

EXTERNALITIES : The other soical costs besides the actual cost of the product, eg. the social cost of polluting industry harming public health.

F

FAUNA : The animals and animal-life of a region.

FISSILE : Fissionable, all radioactive isotopes are fissile materials; usually radionucleides that are splitted in nuclear reactors to produce energy.

FLORA : Groups of plants growing naturally in a region.

FLY ASH : Fine particles of noncombustible fraction of a solid burning fuel like coal carried away by air draft and spread over a large region; fly ash may be collected and used for brick making and other purposes.

FOOD CHAIN : The series of organisms involved in the passage of energy of food from the primary producer (plant) to the series of consumers through herbivorous animals to different levels of carnivores.

FOREST : Large land area with a natural assembly of trees and shrubs (or trees planted by man) and animals with trees as the dominant members of the community.

FOSSIL : The remains, traces, impressions of an organism, large or small, of past geological ages in the earth's crust in petrified form.

G

GAIA HYPOTHESIS : The Gaia hypothesis (developed by British biochemist James Lovelock) considers the whole biosphere as a single functional unit where all the flora, fauna, all biotic and abiotic factors act as a functioning whole in the development of a lasting environment that would preserve itself irrespective of anthropogenic activities and interferences.

GAMMA RADIATION : High energy radiation emitted by certain radioactive compounds (radionucleides), rays are shorter in wavelength than X-rays but longer than cosmic rays.

GANGA ACTION PLAN : A master plan to control the large scale pollution of the most important river of the country (mother Ganga as people call it) by domestic, municipal and industrial wastes and effluents taken up in the early nineteen eighties that envisaged, besides physical cleaning up of certain areas, compulsory treatment of raw sewage and industrial effluents before discharging to the river, periodic monitoring of water quality and various other steps. Although a good beginning has been made much more need to be done on a continuously operating basis to protect the river from abuse and exploitation.

GAS POISONING : Poisoning effect or toxicity due to inhalation of toxic gases such as carbon monoxide and oxides of sulphur, nitrogen etc. The Bhopal gas tragedy was due to methyl isocyanate (MIC) poisoning.

GASIFICATION : The process of converting coal into gas in a gasifier for use in gas-fuelled power stations.

GASOHOL : A mixture of petrol and alcohol (ethyl alcohol, also methyl alcohol) for use as a fuel in internal combustion engines. Ethyl alcohol is usually obtained from fermentation of sugarcane or sugarbeet molasses.

GASTROENTERITIS : A bacterial (also viral) disease of the stomach and intestine accompanied by pain and inflammation of lining of stomach and intestines, diarrhoea often with blood in stool.

GENE : Appropriate unit of DNA (deoxyribonucleic acid) on a chromosome which governs the synthesis of a specific enzyme that is characteristic of the organism concerned.

GENERALIST : Organisms (a species or genus) that are capable of living in widely differing environments.

GEOTHERMAL ENERGY : The energy (heat) coming out of the very hot interior of the earth; eg. hot springs; harnessing geothermal energy for commercial use would save fossil fuels.

GLOBAL WARMING : The slow gradual rise in the temperature of the earth due to emission of excess quantities of a number of radiation-trapping gases [such as carbon dioxide, methane, chlorofluorocarbons, ozone (tropospheric), nitrogen oxides], collectively called "green house gases" (as they prevent radiating back of heat rays as in a glass house for growing green plants — also called a green house).

GREEN CONSUMERISM : A popular movement which encourages people to buy and go for environment-friendly (ecofriendly) items for food as well as other consumer goods.

GREEN ENERGY : Power generated from non-conventional sources of energy — solar, tidal, wind etc. that do not cause pollution or produce wastes.

GREEN POLITICS : Ecofriendly political thoughts and proposals advocated by environmentalists.

GREEN HOUSE EFFECT : A rise in temperature of the atmosphere due to rise in the levels of certain gases (carbon dioxide, methane, chlorofluorocarbons, water vapour etc.) that prevent heat loss in a manner similar to the trapping of heat in a glass-covered 'green house' (used commercially in the temperate countries for raising vegetables and flowers during cold winter months).

GROWTH RINGS : Annual rings, layers of wood produced annually as seen in cross sections of the stem, attributable to seasonal variations in the rate of deposition of building materials and their composition and degree of compaction.

H

HALOPHYTE : A plant which is adapted to saline conditions (also shows some drought tolerant xerophytic characters).

HAY FEVER : An allergic reaction of the body of susceptible people to pollens, spores or dust particles floating in the air, fever accompanied by nasal catarrh, conjunctivitis, skin rashes etc.

HEALTH : The condition in which the body is sound and mind is free.

HERBICIDE : A substance that kills a plant on contact (contact herbicide, eg. dinitrophenol, diquat) or systemically through absorption by plant (systemic herbicide, eg. 2,4-D).

HEREDITY : The genetically desired traits and qualities obtained from parents and ancestors.

HOLISTIC APPROACH : Dealing with something in its totality rather than in parts or sections.

HOMEOSTASIS : A relatively stable state of equilibrium in organisms that resists major changes within an organism even when external conditions show large fluctuations.

HOT SPOT : A place showing higher background radiation than what is normal, very often indicating presence of radioactive materials.

HYDROGEN ION CONCENTRATION : Number of grams of hydrogen ions per litre of solution that gives a measure of acidity of the solution and is usually expressed as pH which is the negative logarithm of the hydrogen ion concentration (pH = $\log_{10}\frac{1}{[H^+]}$; pure water at ordianry temperatures dissociates slightly into H^+ and OH^- ions ($H_2O \rightleftharpoons H^+ + OH^-$) giving 10^{-7} gram molecules of each type of ion, the pH will be $\log_{10}\frac{1}{10^{-7}} = 7$ which represents neutrality on the pH scale, if acid is added the $[H^+]$ will increase and pH will decrease, if alkali is added pH will increase (pH below 7 indicates acidity, a pH in excess of 7 indicates alkalinity).

HYDROLOGICAL CYCLE : The cycle that incorporates the events starting from evaporation of water of the sea by solar radiation, formation of cloud, precipitation on land and sea, and final return to the sea.

HYDROPOWER (HYDROELECTRIC POWER, HYDEL POWER) : Electric power obtained by using water to drive the turbines.

HYDROPHYTE : A plant adapted to aquatic, marshy habitat.

HYDROSPHERE : All sources of water taken as a whole, namely water in the oceans and seas, in land (lakes, rivers, ponds etc.) and in the atmosphere.

HYPERPARASITE : A parasite on another parasite.

HYPERSENSITIVE : Very high sensitivity to certain conditions, for example atmospheric or food allergens.

HYPOTHALAMUS : A small part of the brain situated above the pituitary gland that controls the production of hormones concerned with the regulation of autonomic functions such as hunger, thirst, etc.

I

INCINERATION : The process of burning waste materials to ashes in a special furnace (or incinerator).

INDUSTRIAL DISEASE : Disease that may be attributed to an industrial process through release of fine particulate matters, toxic gases, chemicals and other pollutants.

INFESTATION : The spread of an insect pest or a parasite or pathogen in large number that may cause a lot of harm.

INSECTICIDE : A substance that kills an insect such as the organochlorine (eg. DDT) and organophosphorus (eg. malathion) compounds.

INTEGRATED PEST MANAGEMENT (IPM) : A holistic approach for control of agricultural pests incorporating appropriate cultural practices, biological control, if possible, along with minimal use of toxic chemical pesticides.

INTERNAL COMBUSTION ENGINE : The type of engine in which the fuel, a mixture of petrol and air is burnt in a closed combustion chamber for generation of the rquired energy for moving the pistons.

INTERTIDAL ZONE : The zone of shore lying in between the high and low tide marks (portion that is only periodically submerged).

IRRADIATION : Exposure to radiation in general but more specifically to ionizing radiation for sterilization of food at low doses and using X-rays for medical diagnosis, γ-rays for radiotherapy of cancer, or for producing point mutation in plants etc.

ITAI-ITAI DISEASE : A very painful (itai = pain) bone disease caused by cadmium poisoning first reported from Japan with 95% of the victims being post-menopausal women of over fifty years of age.

J

JET STREAM : Fast-moving air stream at the top layer of troposphere near the tropopause, of the mid latitude region, blowing generally in the form of narrow meandering current from a westerly direction and often exceeding a wind speed of 400 km per hour; also the flow (blast) of gases from a jet engine.

JUNGLE : Tangled mass of thick vegetation, usually tropical trees and shrubs of diverse nature, often difficult to penetrate.

JUVENILE : Young animal or plant that requires a relatively long period of development before maturity.

K

KALA-AZAR : A tropical disease caused by the parasitic protozoa ***Leishmania*** spread by flies (sand fly), the symptoms are fever, anemia, swelling of spleen, liver etc.

KNOCK : Noise caused in an internal combustion engine during the burning of a fuel-air mixture usually in the presence of insufficient petrol in the mix., tetraethyl (or tetramethyl) lead is used as an additive to petrol as an anti-knock measure, but recently sale of 'leaded' petrol is banned because of lead pollution through exhaust gases.

KWASHIORKOR : A malnutritional protein deficiency disease of the children of the third world countries, the common symptoms are enlarged abdomen but thinner limbs, anemia and general wasting of the body; diet (that is usually starch-rich), supplemented with proteins (vegetable and animal proteins) would bring speedy recovery.

L

LABEL : Written information given on a product marketed for the consumer that includes in case of a health related product, the nature of product, origin, date of preparation, date of expiry, price and all relevant facts the consumer is entitled to know.

LAKE BLOOM : Profuse growth of aquatic vegetation especially aquatic algae often due to organic sewage effluents, usually accompanied by a reduction in dissolved oxygen concentration in water.

LAND REFORM : A government policy of taking over surplus land usually from absentee landlords and granting the rightful ownership of the land to the actual tiller of the soil.

LAND SLIDE (LAND SLIP) : The rapid downward movement of a mass of earth or a block of rock or an artificial land fill made of waste materials and earth; landslide is common in hilly or mountaneous terrains during the rains especially when the trees and other vegetation have been cleared from the mountain slopes. The slope of the terrain particularly its degree of inclination, the extent of deforestation, the amount and nature of precipitation, seepage and flow of water are important factors in landslips.

LEISHMANIASIS : A disease caused by minute protozoons *(Leishmania sp.)* transmitted by the sand fly, eg. kala-azar.

LICHEN : A highly specialized form of complex thallophytic plants made up of symbiotic association of a photosynthetic alga and a saprophytic fungus on a solid surface such as a rock or on the trunk of a tree, sensitive to air pollution.

LIGNITE : A type of soft coal with a relatively high percentage of hydrocarbons.

LIMNOLOGY : The scientific study of physical, chemical and biological conditions of fresh water bodies of lakes, rivers etc.

LIQUIFIED PETROLEUM GAS (LPG) : Mostly propane, butane and their combination obtained by refining petroleum, cooled and bottled for domestic use.

LITHOSPHERE : The solid part of the earth consisting of native rocks, rocks at different stages of weathering, soils of differnet kinds etc.

LITHOTROPH : An organism that uses reduced inorganic compounds as electron donors (energy sources) for nutrition.

LOCAL AUTHORITY : An official body responsible to a higher body doing some of the administrative and welfare work of the locality eg. Panchayats.

LOW-WASTE TECHNOLOGY : Advanced technology that generates much less waste material without adversely affecting productivity.

M

MACRONUTRIENTS : Essential elements relatively large quantities of which are required for growth and development of organisms (requirements may differ for different organisms).

MAGNETO HYDRO DYNAMICS (MHD) : A method of generation of electricity (yet to be commercialized) in which the free electrons in a high velocity flame (or plasma) are subjected to a strong magnetic field, the flow of electrons in between the two electrodes within the flame under the influence of the strong magnetic field would constitute the current.

MALNUTRITION : Lack of proper nutrition, starvation or improper absorption of nutrients from the food; chronic malnutrition especially of the children is prevalent in some developing countries of the third world.

MAN : A human being — a bipedal mammalian primate related to the great apes but with greater development of the brain resulting in greater power of abstract reasoning and better articulated speech faculty. Man ***(Homo sapiens)*** is the sole non-extinct representative of the family, ***Hominidae*** and consists of a variable number of freely interbreeding races distributed across the globe. The future of the biosphere depends greatly on the nature of interaction between man and environment.

MANGROVE : A tropical maritime vegetation of shrubs and trees which are especially adapted to salt water swamps in the estuaries of big rivers in Asia and America with ***Rhizophora, Avicennia, Bruguiera*** and ***Ceriops*** as the dominant species of plants.

MATURATION LAGOON : A large pond into which the sewage is collected in the final stage of treatment.

MEGALOPOLIS : A very large urban unit. Often agglomeration of a number of adjacent small towns into a very big urban unit.

MELANOMA : Malignant tumor containing dark pigments believed to be caused by over exposure to sunlight.

METAMORPHIC ROCK : A rock, the formation of which was effected by pressure, heat or water in such a way that it has become more compact and crystalline.

METROPOLIS : A city or town that is a major centre of activity.

MICROECONOMICS : Economics dealing with small items such as, a single product, a small trade etc.

MINAMATA DISEASE : A mercury poisoning disease due to eating fish from mercury contaminated water of the Minamata bay of Japan (disease named after the place of first report i.e. Minamata).

MONOSODIUM GLUTAMATE (MSG) : A crystalline sodium salt of glutamic acid ($C_5H_8O_4NaN$) used for seasoning and flavouring food.

MONTREAL PROTOCOL [MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER] : A successful agreement made under the auspices of the United Nations in 1987 to phase out production and release of substances that are responsible for the destruction of the protective ozone layer (the protection by ozone involves the blocking of the ultraviolet radiation emitted by the sun), particularly by the chlorofluorocarbons (CFCs) and also several other ozone-depleting chemicals. An amendment to the protocol was made in 1992 and signed by 93 nations including India and China agreeing to eliminate the use of CFCs, carbon tetrachloride and halogens by 2000 AD and methyl chloroform by 2005 AD.

MOON : The only known natural satellite of planet earth (with a mass of about one eightieth of the earth and mean distance of about 3.8×10^5 km from the earth) moving in an elliptical orbit round the earth in about 27.5 days (one complete moon cycle with four phases — full moon, new moon and two half-moons) shining in the sun's reflected light; the moon besides its aesthetic appeal and other unknown effects on the earth's abiotic and biotic systems directly influences through gravitational effect the tides in the oceans and waterbodies connected with the ocean.

MORBIDITY RATE : The number (rate) of incidence of a disease per thousand population.

MUTAGEN : An agent that is capable causing mutation (a hereditary genetic change) such as ionizing radiations, chemical mutagenic substances etc.

N

NATURE : The visible and perceived world with all its abiotic and biotic natural resources.

NATURE CONSERVATION : Maintenance of a favourable balance of nature with respect to the quantity and quality of the physical components of nature through prevention of over-exploitation of nonrenewable natural resources, effective trapping of renewable resources, preservation of biodiversity and judicious management practices to avoid undue conflict between economic development and environmental degradation.

NATURAL RESOURCES : Mineral deposits, water, air, plant and animal resources, in the lithosphere, hydrosphere, atmosphere and biosphere.

NATURAL SELECTION : An essential component of the evolutionary process : selection in nature of organisms with such heritable characters (with required genetic changes brought forward by mutation) that enable them to adjust to changed conditions imposed by nature, and elimination of those who cannot.

NEIGHBOURHOOD NOISE : The noise produced by a local source such as a factory or a very busy highway passing through the locality and any other sources of noise often characteristic of the particular locality.

NETWORK : An interconnected or interrelated system of communication (including wireless communication), channels, groups etc.

NGO [NON GOVERNMENTAL ORGANIZATION] : An organization that works outside the government either independently or in collaboration with other public or private institutions, charitable organizations, trusts and endowments on issues relating to various aspects of environment (or other activities) through a range of actions, often even direct nonviolent physical resistance to achieve the goal. Since the 1992 Earth Summit in Rio de Janeiro in which over 9000 delegates of the NGOs assembled, they have drawn considerable international attention in their moves to safeguard the environment. However, the recent mushrooming of NGOs has since brought up questions on credibility, authenticity of purpose and efficacy of many of them.

NICHE : A place of special habitat within an ecosystem that supplies the necessary factors for the existence of an organism or species.

NOISE : Sound usually of a high level that is noticeably unpleasant, disturbing and causes annoyance.

NOISE POLLUTION : The act of damaging the tranquility of the surroundings with high levels of unpleasant, disturbing and annoying sound.

NOMAD : A person who does not settle permanently in a particular place but keeps on moving, staying only in temporary shelters eg. herdsmen who graze cattle and sheep, nomadic hunters etc.

NONBIODEGRADABLE : Not decomposable by biological means, implying that the enzymes that break up complex synthetic substances are as yet nonexistent in nature.

NONDEGRADABLE : Not possible to degrade or decompose naturally by agents (physical, chemical or biological) present in the surroundings.

NONRENEWABLE RESOURCES : Usually an exhaustable natural resource which cannot be replaced, e.g. coal, petroleum etc.

NUCLEAR BOMB : An atomic bomb in which the explosive power is derived from nuclear fission or nuclear fusion.

NUCLEIC ACID : Polynucleotide such as deoxyribonucleic acid (DNA) or ribonucleic acid (RNA) — a nucleotide is composed of a nitrogenous base, a pentose sugar and phosphate — many such nucleotides combine to give rise to a polynucleotide (nucleic acid)

O

OASIS : A small green patch usually around a water hole in a desert area with an otherwise extremely arid landscape.

OCCUPATIONAL DISEASE : A disease the occurrence of which can be attributed to the occupation of the person, specifically to the microenvironment of the work place — floating dust particles, fibres, chemical fumes, high noise level etc.

OCEAN DUMPING : Discharging liquid and solid wastes (including radioactive wastes in sealed corrosion resistant leak-proof containers) into the ocean.

OCEAN THERMAL ENERGY CONVERSION (OTEC) : A potential source for generation of power (electricity) utilizing the large difference in the temperature of upper and lower layers of a tropical ocean water. The method is yet to become commercially viable.

ODOUR : Smell; the quality of a substance that stimulates or sensitizes the olfactory nerves; the term is usually used to mean unpleasant smell.

ODOUR NUISSANCE : Unpleasantness and annoyance due to bad smell may be from sewage, garbage dump, morgue, tannery, etc.

ORGANOCHLORINE COMPOUNDS : The group of chlorine containing synthetic organic compounds (chlorinated hydrocarbons) that are potent insecticides eg. aldrin, dieldrin, endrin, heptachlor, DDT, BHC (gammexane), etc.

ORGANOPHOSPHORUS COMPOUNDS : Phosphorus containing synthetic organic compounds used as insecticides, eg. malathion, parathion, diazinon, etc.

OZONE DEPLETING POTENTIAL (ODP) : The capacity of certain chemical substances such as chlorofluorocarbons (CFCs), oxides of nitrogen, chlorine, methane etc. to destroy (break up) ozone molecules in the stratospheric ozone layer.

OZONE HOLE : The creation of a very thin area or "hole" in the stratospheric ozone layer because of destruction of ozone molecules through reaction with chlorine molecules (especially from chlorofluorocarbons, CFCs), nitrogen oxides from fossil fuels in presence of water molecules, molecules of methane gas etc.

P

PAH [POLYCYCLIC AROMATIC HYDROCARBONS] : A group of chemicals with many industrial uses, but are toxic to man; naphthalene, anthracene, pyrene, benzo (a) pyrene with 2, 3, 4 and 5 rings respectively are some of the members of the group. PAHs are often products of incomplete oxidation of fossil fuels, garbage incineration process etc.

PAN [PEROXYACETYL NITRATE] : A substance present in low concentrations in photochemical smog.

PASTEURIZATION : Partial sterilization of a fluid such as milk at a temperature that destroys objectionable microorganisms without adversely affecting the physico-chemical properties or quality of the liquid.

PATENT : An official privilege or right that confers to an inventor of a new product or a scientific process the exclusive rights to make, use and sell the invention for commercial exploitation for a specific term of years.

PBB [POLYBROMINATED BIPHENYL] : Aromatic compounds containing benzene and bromine used in plastics and fire retardant materials, highly toxic fat soluble compounds, believed to be carcinogenic, very persistent.

PCB [POLYCHLORINATED BIPHENYL] : Similar to PBB except that bromine has been substituted by chlorine, fat soluble highly toxic chemicals that persist for a long time.

PEAT : Decayed and partly decomposed vegetation (mosses and other plants) that has become partially carbonized, quite often found in bogs and boggy soils.

PERSISTENT ORGANIC POLLUTANTS (POPs) : Compounds which are extremely resistant to natural degradation, persist unaltered with the possibility of bioaccumulation (accumulation in different organisms) and biomagnification (gradual increase in concentration within the body of organisms). The polycyclic aromatic compounds, particularly the organochlorine compounds such as polychlorinated biphenyls (PCBs) polybrominated biphenyls (PBBs), polycyclic aromatic hydrocarbons (PAHs), many of which are widely used in agriculture and industry are all of the persistent type and are therefore ecologically hazardous.

PHOSGENE : A colourless toxic gas (carbonyl chloride, $COCl_2$) of unpleasant smell, has been used as a war gas (chemical warfare). The lethal concentration for rats is only 50 ppm, with relatively high concentrations fatal pulmonary edema may occur in man.

PHOTOCHEMICAL POLLUTION : Polluting substances produced by photochemical reaction (light induced chemical reactions), eg. photochemical smog.

PHOTOSYNTHESIS : The process by which green chlorophyllous plants utilize the energy of sunlight for synthesis of food (usually carbohydrates, initially) from carbon dioxide and water and release oxygen (from the breakdown of water) as a byproduct.

PHOTOTROPHIC ORGANISM : Organisms (chlorophyllous green plants) that can synthesize their own food by photosynthesis (initially carbohydrates and subsequently converting carbohydrates to other vital metabolites such as proteins, fats etc.)

PHYTOPLANKTON : Minute aquatic plants that float or drift on water, especially abundant in sea water serving as food for small aquatic animals.

PLATE TECTONICS : A geologic theory suggesting the structure of earth as one lying on a series or rocky plates of huge dimensions floating on the liquid (molten) mantle, touching or meeting of adjacent plates would result in the shaking of earth's crust.

PNEUMOCONIOSIS : A chronic respiratory disease affecting the lungs caused by the habitual inhalation of mineral or metallic particles.

POIKILOTHERM : Cold-blooded animal with body temperature that changes with the outside temperature.

POLLUTER : A company or a person that is responsible for pollution of the environment, for example a paper mill, an asbestos factory; a person who throws any sort garbage in a public place etc.

POLLUTION : Naturally-occurring or man-made processes by which the usually favourable natural conditions for a healthy living is disturbed or disrupted; pollution of air, water and soil being areas of especial emphasis.

POLYCONDENSED PLASTIC : A kind of plastic not usually degraded and is therefore recycled.

POLYTHENE : Polyethylene — a tough thermoplastic chemically resistant flexible material produced by polymerization of ethylene (C_2H_4), used as a good electrical insulating material and various other purposes.

POPULATION CONTROL : Controlling increase in the number of people in a region or country by various means of contraception.

POTABLE WATER : Water safe and suitable for drinking.

PVC (POLYVINYL CHLORIDE) : A white thermoplastic material produced by polymerization of vinyl chloride ($CH_2 = CHCl$), which has good resistance to acids, alkalis and alcohols and has many industrial and commercial uses.

PRAIRIE : Plain grass-covered land in North America (also in Canada) especially the vast area of rolling land in the Mississipi valley with rich fertile soil.

PRECIPITATOR (ELECTROSTATIC) : A device for precipitating fine particulate matters — dust, ash etc. by passing them through a charged electrostatic field.

PRIMARY COLOUR : Basic colours in the spectrum, green, blue and red from which all other colours may be derived.

PRIMARY CONSUMER : An animal that eats plants — a herbivore (herbivorous animal).

PRIMARY PRODUCT : A product that serves as the basic raw material for other products for example milk, cotton, jute etc.

PRIMARY PRODUCTIVITY : The rate of production of organic matter by photosynthesis.

PRIMARY SUCCESSION : The initial ecological community on a bare surface.

PROTOPLASM : All the inclusions of the living cell consisting of the nucleus, the cytoplasm, plastids (in plant cells), mitochondria, ribosomes and other organelles, and proteins, organic substances, minerals in an aqueous medium.

PUTREFACTION : The decomposition of organic matter, specifically anaerobic breakdown of proteins by bacteria.

PYRAMID OF BIOMASS : Graphic figure showing the different amounts of biomass at each trophic level with the highest at the primary producer level at base and lowest in highest consumer level at the apex

Q

QUADRAT : A small area of land measuring one square metre (1m x 1m) chosen as a sample for ecological population studies usually on small vegetation.

QUOTIENT : The number resulting from the division of one number by another; intelligence quotient — the ratio of test score (giving the mental age of a child) and the actual age and multiplying that by 100; respiratory quotient — ratio of carbon dioxide given off and oxygen taken up in respiration.

R

RAD : The unit of absorbed dose of ionizing radiation, one rad is equal to the energy absorption of 100 ergs per gram of irradiated material.

RADIATION HAZARD : The potential danger to health resulting from exposure to ionizing radiation from radioactive materials, X-rays etc. or inhalation or consumption of radioactive substances.

RAINFALL : The amount of rains that fall in an area over a period of time usually measured in centimetres or inches.

RAINFOREST : Thick tropical forest growing in an area with high rainfall usually over 250 cm.

RAW MATERIAL : Material used for manufacture of finished products for example iron ore for making steel, cotton lint as raw material for cloth etc.

RECYCLING : Processing of waste materials for reuse — metals, glass, paper, plastic etc. can be recycled and reused (recycling is an environment-friendly process and is officially encouraged).

RELATIVE HUMIDITY : The ratio between the amount of vapour in air and the amount that would be present if the air was fully saturated (expressed as percentage).

RESPIRATION : The enzyme catalyzed process of oxidative breakdown and release of energy of food substances (in which energy is stored in carbon-carbon chemical bonds) for energy requiring processes in biological systems, as accomplished in higher animals (a mammal like man) by continuous breathing (inhalation of oxygen containing air and exhalation of carbon dioxide-rich moist spent air).

RHIZOBIUM : Symbiotic nitrogen-fixing bacteria that reside in the root nodules of leguminous plants (peas, beans etc.) getting nutrition from the host and supplying biologically fixed nitrogenous compounds to the host (usually on death and decay).

RIBOSOME : A protoplasmic inclusion (a minute microscopic organ or organelle) containing ribonucleic acid (RNA) that is the seat of intracellular protein synthesis.

RIO DECLARATION : The directive principles of environmentally-sound developments contained in the 27-page document approved at the 1992 Earth Summit (held at Rio de Janeiro, Brazil) of the heads of the participating governments of different countries.

RUN-OFF WATER : The volume of water from rainfall or melted snow that has been carried away.

S

SAFE DOSE : Dose of medicine that is not harmful; dose of radiation that can be absorbed by the body without causing harm.

SALINITY : The degree or extent of saltiness of a solution of salt in water.

SALMONELLA : Rod-shaped aerobic usually motile bacteria of the genus ***Salmonella*** that are pathogenic in man and warm-blooded animals causing food poisoning, severe gastrointestinal disorder and also diseases of the genital tract.

SAPROPHYTE : An organism that lives on dead and decaying organic matter.

SAVANNAH : Tropical or subtropical grass land in Africa, South America, North America (Florida) etc. with scattered trees and drought resistant plants (in the tropics).

SCRUBBER : A device for removing inpurities and fine particulate matters especially from gases; cleaning waste gases by removing sulphur and other pollutants, etc.

SEA FARMING : Marine aquaculture for the production of edible sea weeds, shellfish etc.

SEDIMENTARY CYCLE : Rocks that are weathered to silty particles which may be turned to rocks again when such silty sediments are allowed to settle at the bottom of a lake or sea.

SEPTIC TANK : A tank in which household sewage, human excreta in particular, accumulate and undergoes anaerobic decomposition.

SEVESCO : Italian town where an industrial disaster occurred in 1976 — the escape of dioxin (TCDD — tetrachlorodibenzo-*p*-dioxin) gas killed over eighty thousand fouls and half of the pigs in the town.

SEWAGE : Waste water, human excreta etc. flushed down the toilets and carried away by the sewers.

SEWAGE TREATMENT PLANT : An area with accessories and equipments for treatment and purification of liquid sewage for safe disposal to a river or sea.

SEX EDUCATION : Education on all aspects of sex, especially of the human. The evolution of sex has been a very big step forward in the origin of species and is rightly considered to be one fo the greatest events in biology . A clear understanding of the morpho-physiological and behavioural aspects or sex is now considered essential for our young people to remove any misconception about sex and also to develop the right attitude towards sex. Introduction of sex education at the late school or middle school stage is therefore strongly advocated by most progressively minded people including physicians, sociologists, social psychologists and educationists.

SHELLFISH : Aquatic invertebrate animal covered with a shell, especially edible mollusks and other crustaceans.

SHOCK WAVE : A compressional wave (wave due to a release of tremendous pressure) formed whenever the speed of a body relative to a medium exceeds that at which the medium can transmit sound, as may happen in case of atomic blasts.

SILENT VALLEY : The site for a proposed highly controversial hydroelectric project by building dams across river Kunthipura in the Palghat district of north Kerala, India that attracted national and international attention because its implementation would have destroyed an ecologically important primitive rainforest with rare flora and fauna. In view of the tremendous pressure mounted against the project by leading environmentalists and organizations like Kerala Shastra and Sahitya Parishad (KSSP) who played a key role in arousing public awareness and interest, the Silent Valley Hydel project was ultimately shelved.

SILICOSIS : A chronic disease of the lungs (pneumoconiosis) caused through inhalation of fine silica dust especially from stone crushing industries.

SLUM : Highly congested area usually within the city limits (often located centrally) with very poor living conditions in unplanned poorly constructed houses and hutments on very narrow lanes or passages with extreme lack of sanitary facilities inhabited by poor people who are mostly engaged in manual works as daily wage earners, domestic hands, hawkers etc.

SMOG : A relatively dark, smoky, fine dust- and soot-containing fog which under certain meteorological conditions such as temperature inversion (temperature lower at ground surface than in air above) tend to hang over the ground surface for a considerable period and results in poor visibility and serious respiratory problems; photochemical smog is attributed to the photochemical action of ultraviolet rays in sunlight on unburnt hydrocarbon and oxides of nitrogen in the exhaust fumes and smokes of cars and engines, producing smog with traces of toxic ozone gas (tropospheric).

SOFT WATER : Water that easily forms lather with soaps and does not contain salts of calcium, magnesium and often iron.

SOIL POLLUTION : The act of damaging the quality of soil by dumping of garbage, rubbish, municipal wastes containing toxic substances, industrial effluents containing hazardous chemicals, excessive and indiscriminate use of agricultural chemicals such as fertilizers, fungicides, insecticides, herbicides, etc. Soil may also be polluted by deposition of wind borne sand and silt, and in areas adjoining thermal power stations fly ash deposition damages crops and soils. Many pesticidal residues are often persistent and harmful to the beneficial soil microflora. The large scale use of the hormonal defoliant. Agent Orange by the American forces in the Vietnam War rendered the affected soil virtually unfit for cultivation for a considerable period. Contamination of soil by radioactive materials (nuclear wastes deposition through accidents or use of land as atomic test sites) may render the soil useless for productive purposes.

SOLAR CELL : A photoelectric device that converts the energy of sunlight to electricity.

SOLAR DRYER : A device for the utilization of sunlight for generating heat for drying.

SOLID WASTE : Waste matter that is relatively hard and cannot be put directly into the drain pipes.

SPILL : A liquid that has come out accidentally from the container as in oil spills from oil tankers in seas causing serious environmental hazards.

STORM : Atmospheric disturbance caused by gale-force winds accompanied most often by thunder and rains.

STRATOSPHERE : Upper atmosphere above the troposphere and below the mesosphere, approximately between 11 and 50 km depending on latitudes, seasons etc.

SULABH SANITARY MOVEMENT : A successful sanitation movement which is concerned with the generation of public awareness on sanitation and extension of clean toilet facilities in many urban cities of the country with nominal charges from the user thereby directly helping in keeping the local environment clean.

SUN : A star of the Milky Way galaxy of the universe and is the central figure of the solar system consisting of nine planets, including our planet earth and a belt of asteroids that revolve round the sun in nearly circular orbits in nearly the same plane. The sun having a mass of 2×10^{30} kg (i.e. 332900 times the mass of the earth) is about 150 million km away from the earth requiring 8.3 minute for sunlight to reach this planet. The sun is the ultimate source of energy (the tremendous energy of the sun originates from the thermonuclear fusion of hydrogen to helium) on earth and all forms of life on this planet owe their existence to the sun.

SUNDARBANS : Riverine delta region in the Ganga estuary on the Bay of Bengal built up of silt and mud deposits

2-2.5 billion tons per year washed away and brought from the vast basin area of the river over ages. The area is characterized by a specialized unique vegetation and equally adapted fauna. The Sundarbans occupy an area of about 10,000 sq km of which more than half falls in Bangladesh (the estimated area in West Bengal is 4264 sq km) and is crisscrossed by tidal canals. As such, much of the coastal areas remain periodically submerged depending on the tides and the flora and fauna in this unique ecosystem, known as the mangrove ecosystem, adapt wonderfully to the daily periodic submergence and recession, the semisalinity or salinity of water (depending on the season and the extent of mixing of river water and salty sea water of the bay). The flora include highly specialized plants such as ***Rhizophora, Avicennia, Sonneratia, Nipa, Bruguiera*** etc., some with distinct xerophytic features (because salinity affects water uptake), stilt roots for stability on loose muddy substrate, breathing roots for taking air from oxygen- deficient wet mud, more so during submergence, and viviparous germination (germination of seed while still attached to the mother plant) so that the partly developed seedling can establish successfully in the hostile environment below. Various types of fish, some with amphibian habits, crustaceans with specialized features also thrive well. Deer, wild pigs, reptiles and crocodiles and a range of birds and insects (bees in particular) are typical animal members with the famous Royal Bengal tiger remaining as the top predator.

SUSTAINABILITY : The property of something or some action the advantage of which will not end abruptly but will continue to be of benefit to many succeeding generations eg. afforestation of denuded land (in fact, most ecofriendly actions would be sustainable).

SYNDROME : Signs and symptoms occurring together showing or suggesting the characteristics of a particular abnormality or disease.

T

TECHNOSPHERE : The world (sphere) of technology; artificial human-built so-called "sphere" of technology encompassing all conventional and on-going technologies including nuclear power technology and the more recent revolutionary electronics based information technology all of which have direct or indirect interactions with the environment.

TEMPORARY HARDNESS (OF WATER) : The hardness of water due to the presence of bicarbonates of calcium and magensium that can be cured by boiling which precipitates the bicarbonates as insoluble carbonates of calcium and magnesium.

TERTIARY INDUSTRY : Industry that is not involved in producing primary or basic goods and raw materials (primary industry) or manufacturing finished products (secondary industry) but engaged in giving services (such as banking insurance, transport etc.).

TETRAETHYL or TETRAMETHYL LEAD/LEAD TETRAETHYL : Antiknocking or antifouling agent added to petrol; because of lead pollution use of this additive has now been discontinued in many countries.

THERMAL POLLUTION : The adverse effect of a rise in atmospheric temperature due to release of heat such as from a power-plant cooling tower.

THIRD WORLD : A popular term for the developing countries of Asia, Africa and Latin America (the powerful capitalist countries form the First World, the disintegrated "Communist Block" countries constitute the Second World and the nonaligned less developed countries or developing countries (previously underdeveloped countries) form the so-called Third World.

THREE MILE ISLAND : The scene of an accident and near melt down of the reactor in 1979 in the nuclear power station in Pennsylvania, USA that brought forth world-wide concern over the safety of atomic power plants for generation of electricity.

THUNDERSTORM : Gale-force winds (often violent) with rains accompanied by thunder and lightning.

TIGER PROJECT : This successful wildlife conservation project was taken up with a generous financial grant by the World Wildlife Fund (WWF) in nine forest zones of the country (with a total of 27 tiger reserves in 1999) with the major focus on the Sunderbans to check the rapid decline in tiger population primarily due to illegal poaching. The tiger population in India which went down to approximately 1800 in 1965 rose to over 4000 in 1985.

TRANSBOUNDARY POLLUTION : A kind of pollution that crosses geographic boundaries, the gaseous pollutants of an industry in one country may pollute air of other countries.

TRICHLOROPHENOXYACETIC ACID : 2,4,5-Trichlorophenoxy acetic acid, a herbicide or weed killer, constituted about 50% of the Agent Orange (the other half 2,4-D) extensively used by the U.S. army in the Vietnam War.

TURBINE : Conventionally, a mechanical device for conversion of the energy of falling water into electricity; a motor the shaft of which is steadily rotated by the impact of a very strong current of steam, air, water or any other fluid directed upon the blades of a wheel.

TYPHOON : A tropical cyclone so named when occurring in the far east especially in the Philippines region and China Sea.

TYPHUS : A severe disease causing high fever, intense headache, dark red rash on the body caused by the microorganism *Rickettsia prowazekii,* that is transmitted by body lice.

U

ULTRAVIOLET RAYS (UV RAYS) : Rays having wave length shorter than the wavelengths of visible light but longer than X-rays (range of wavelength 5 to 400 nm.).

UNEP [UNITED NATIONS ENVIRONMENTAL PROGRAMME] : The United Nations have been deeply concerned with the ongoing environmental degradation and over the years took major initiatives to safeguard the environment of the world by arranging major conventions and formalizing international treaties such as the Antarctic Treaty, 1959; Montreal Protocol on Ozone-Depleting Substances, 1987, Biodiversity Convention, 1992, etc.

: A strict vegetarian who eats food of vegetable origin avoiding milk, eggs etc.

Submicroscopic infection-causing agent, visible under the electron microscope, considered to be an object in
living and nonliving, consists of nucleic acids (DNA in DNA-viruses, RNA in RNA-viruses) coated with pro-
d functional only within the body of the host where the virus takes over the metabolic machinery of the host
nultiplies itself in the same way as genes (nucleic acid) but the rate is much more rapid, the viruses are respon-
a large number of diseases of plants and animals.

SPOSAL : The methods involved in dumping of wastes whenever necessary after ensuring that the matter
. disposal.

IANAGEMENT : All the procedural and managerial work involved in collection, treatment and disposal of

TREATMENT : Treatment of waste including separation, recycling and reuse of certain things and treatment of
lizable things for safe disposal.

R : The most common liquid on the earth, chemically a compound of hydrogen and oxygen (H_2O), water is insep-
ble from life.

ATER BALANCE : A situation where the gain and loss of water are equal.

WATER POLLUTION : Any man-made or natural act that adversely affects or changes the usual physico-chemical and biological characteristics of water. Pure water is a simple chemical compound of two hydrogen atoms bonded to an atom of oxygen, but natural water, except usually in rains and snows, almost always contains physical, chemical and biological inpurities, may be in traces. The common sources of pollution are sewage contamination (pathogenic microorganisms, chemical salts, organic matter etc.), industrial effluents (wastes from petrochemical complexes, fertilizer and other agrichemical industries, sugar textile, paper, leather and pharmaceutical industries etc.), agricultural chemicals (fertilizers, pesticides, etc.), farm wastes, etc. which need to be controlled through various methods of treatment.

WATER QUALITY : The extent of purity of water for drinking as well as for various other uses. As such, water quality standards would be different for different purposes.

WATER REQUIREMENT : The amount of water necessary for various domestic (drinking, bathing, washing etc), agricultural and industrial purposes. Water requirement for irrigation is very high and for one kg of rice 4400 kg of water would be necessary, the amount for 1 kg of cotton lint is 16000 kg; for one kg of paper produced in the factory the water requirement is 362 kg while for a kg of aluminium the requirement in 3624 kg; and an average automobile would require 362 tons of water for its production.

WATER TABLE : The level of first layer of water below the ground surface.

WEB : An intricate woven structure — a network; a chain or series of interconnected things; energy or food chain in an ecosystem; the term is also used for the membranous tissue that connects fingers or toes at their bases as in frog, duck etc.

WETLANDS : Wetlands form a natural ecosystem having the properties of both terrestrial and aquatic systems with the land remaining submerged at least during a part of the year. The soil is basically undrained giving rise to swamps, bogs and marshes. They also include estuaries and deltas, tidal mud flats and mangroves and even waterlogged paddy fields and shallow fisheries. Wetlands play important role in aquifer recharging, flood control and often serve as partly purified sewage reservoirs.

WWF [WORLDWIDE FUND FOR NATURE, WORLD WILD LIFE FUND] : An international conservation organization founded in 1961, known internationally as World Wide Fund for Nature devoted to all activities in the conservation of natural environment, protection of natural habitat and endangered species, preservation of biodiversity, imparting environmental education etc.

X

X-CHROMOSOME : A chromosome associated with sex determination, the female of most animals has two X-chromosomes besides the species-specific pairs of autosomes (nonsex chromosomes) while the male has a nonhomologous pair of sex chromosomes with only one X-chromosome and a Y-chromosome.

XEROPHYTE : Specialized group of plants morphologically and physiologically adapted to dry edaphoclimatic conditions in arid and semiand desert regions capable of retaining mositure within the body and preventing water loss by transpiration, eg. cacti and succulents.

X-RAY [ROENTGEN RAYS] : X-rays are electromagnetic rays that may pass through tissues and leave images on photosensitive films (wave lengths lie in between ultraviolet and gamma rays, i.e. 6×10^{-3} to 5 nm).

Y

Y-CHROMOSOME : Sex chromosome in the male of most animals, the nonhomologous partner of the X-chromosome (thus the nonhomologous ones XY are the two sex chromosomes of the male besides the usual species-specific number of pairs of autosomes).

YEAST : A fungus of the genus *Saccharomyces (S. cerevisiae,* a very common species), unicellular and bud-forming but lacking mycelia (fine thread-like structures), widely used in the brewery and baking industries as source of enzymes that cause fermentation of sugar (anaerobic respiration with the production of alcohol and carbon dioxide).

Z

ZERO POPULATION GROWTH : A stabilization of population growth at the current level implying that the people are just replacing themselves and a balance between birth and death rates has been reached.

ZOOPLANKTON : Plankton (floating or weakly swimming minute organisms that serve as food for small fishes and other aquatic organisms) consisting of minute fauna (animals) only as different from phytoplankton consisting of minute flora (plants such as algae) only.